A CASE STUDY OF CHEMISTRY TEACHING AND LEARNING IN A TENTH GRADE CLASSROOM IN JORDAN

by

Fathi Hasan Malkawi

A DISSERTATION

submitted to
Michigan State University
in partial fulfillment of the requirements for
the degree of

DOCTOR OF PHILOSOPHY

Department of Educational Administration and Curriculum

1984

ABSTRACT

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The purpose of this study was to describe and interpret the teaching-learning process in a tenth grade science classroom as a way of understanding the quality and effectiveness of science instruction. The study addressed three main components of the teaching-learning process: program materials, actual instruction, and students' learning.

The study used a case study approach and employed ethnographic methods of data collection including participant observation, video and audio recordings, analysis of official documents, and interviews.

Data from observations and interviews strongly suggest that the quantity of subject matter was found to be too much to cover in the time available. In order to cover this amount, the teacher in this study excluded the experimental part of the program and was very demanding in the full utilization of classroom time. The presentation of some topics was found confusing, and the teacher faced problems in teaching them. In some cases, she missed the meaning of what she read in the textbook and assigned other meanings derived from prior experience.

Time was a major factor in understanding many aspects of this classroom's teaching and learning. The teacher practiced a high level of control and influence over the knowledge and social order of the classroom. One major function to which she devoted a great amount of time was that of translating the formal Arabic of the textbook into colloquial Arabic when presenting the material to the students.

Teaching and learning in this classroom were limited to the conceptual knowledge of the course. Many students had problems in learning certain topics as well as general principles and main ideas. They succeeded, however, in learning most of the specifics of the subject matter. Evidence was presented to show that this classroom was representative of many other classrooms throughout Jordan.

The results of this study lend themselves to be utilized readily by policy makers, teachers, and teacher educators in the field. Specific implications and limitations of this study were discussed.

بِسْمِ ٱللَّهِ ٱلرَّحْمَٰنِ ٱلرَّحِيمِ

In the name of Allah the most merciful and the most beneficient

ACKNOWLEDGEMENTS

Many people have contributed to the accomplishment of this work. The first one I would like to acknowledge is the case teacher, Miss Hanan Talib (a fictitious name, as are all names used in this study), whose trust, openness, and understanding were major factors in conducting this study in her classroom. The principal of Northeastern Girls Secondary School should also be acknowledged for her belief in the worth of research.

During the course of my doctoral program, I received guidance, support, and assistance from many individuals at Michigan State University to whom I am deeply indebted, especially my guidance committee: Drs. James Gallagher, Edward Smith, Susan Florio-Ruane, and Paul Hunter. Professor Gallagher, my advisor and chair of the guidance committee, gave me invaluable support, advice, and motivation. The insight and criticism of Dr. Smith were very helpful. Dr. Florio-Ruane, my teacher of ethnography, granted me a great deal of encouragement. My gratitude and appreciation are due all of them.

My family deserves special recognition. My parents in Jordan, my wife Sabah, and my children Lina, Malik, Anas, and Banan have suffered and sacrificed greatly. Their patience and prayers should be acknowledged the most.

Finally, I would like to acknowledge Yarmouk University in Jordan which provided me with the scholarship that made it possible for me to accomplish my doctoral degree.

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CHAPTER I

INTRODUCTION

The Purpose of the Study

The scarcity of research and the lack of studies on chemistry education in Jordan have been documented in a number of references (Nazar, 1980; Malkawi, 1978). Some of the features of chemistry education as seen from research conducted in the United States do not apply in the same way in Jordan, due to the difference in centralization of control of education. Schools and teachers in the United States have a high degree of authority regarding choice of content, standards, and modes of presentation. In Jordan, as in most nations, the Ministry of Education governs all aspects of education in a centralized way by providing a standard curriculum, centralized general examinations, and a cadre of supervisors to help evaluate teachers' performances in implementing the curriculum.

Most of the changes and modifications of curriculum materials, teaching methods, and staffing are based on personal experiences and general impressions of the administrators concerned. Very seldom were these based on research findings or some systematic approach. This also seems to be the case in the United States (Cody et al., 1980). The need for research in science education in general, especially research which aims at understanding the actual practices in classrooms, is obvious. If such research can serve as a diagnostic device to deal with the specifics of classroom teaching and learning of a particular science program, then efforts to improve classroom practices are likely to be more successful.

The present study on chemistry teaching and learning in a tenth grade classroom in Jordan aimed at understanding what happends in that particular classroom. Teaching is the actions in which a teacher provides the necessary conditions to enable students to learn, but learning itself comes down to the individual student in the individual classroom. Teaching activities, students' learning outcomes, and curriculum materials being used were the three foci of this study. The research design adopted here was the case study in which the ethnographic approach was used for collecting data, and both qualitative and quantitative types of evidence were employed. Various aspects of classroom instructional activities have been researched most often using quantitative evidences. Very few studies have been conducted in the qualitative tradition. The major gap in science education research is the lack of studies which address the various contextual factors of the classroom instruction at the same time.

By using a holistic approach and employing multiple perspectives in conducting this study, the researcher hopes to contribute some understanding of teaching and learning science in Jordan and to introduce a research tradition which is still not familiar to the small community of researchers in Jordan.

The rest of this chapter will provide a background about science education in Jordan, the status and priorities of research on science education in Jordan, the research problem, and the research questions of the study.

Science Education in Jordan

During the first nine grades, children study a course in general science every year. At the end of the ninth grade, almost 25% of the total number of students go to vocational schools. The quantity and quality of science received by students in vocational education depend on the type of vocation. Those in agricultural education and nursing education receive intensive courses in biology and chemistry with some physics. Industrial students receive an intensive course in physics and some chemistry. Business students receive general science courses of a descriptive nature.

The other 75% of students continue their academic education. Two science courses are taught for tenth grade students: a course in biological sciences and another in physical sciences. The latter course is an integration of chemistry, physics, geology, meteorology, and astronomy. But the emphasis is given to major scientific concepts and processes.

At the end of the tenth grade, students are divided according to their achievements in science and mathematics into a science branch or a literature branch, with 50% of the total number of students usually entering each branch. All students in the science branch receive the same educational curriculum in chemistry, physics, biology, and mathematics. They spend almost half of their time in science and mathematics in each of eleventh and twelfth grades. Students in the literature branch receive a light course in general science and another in general mathematics in each of eleventh and twelfth grades.

Figure 1 shows the number of periods per week of science and mathematics for each of the twelfth grades in the school system in Jordan. Each period lasts for 40-45 minutes. The fact that there is a certain textbook assigned by the Ministry of Education for each school subject at each grade level to be taught during those assigned periods in the school schedule makes it obvious that science as well as mathematics are considered basic subjects at all educational levels. Science is important for everyone.

During the late 1960s, science education has received some attention, especially in developing new curricula and writing new textbooks. The approach of these curricula and textbooks has ben developed after reviewing various materials developed by that time in the United States, the United Kingdom, and

		SCIENCE		MATHEMATICS		
School Level	Grades	Type of Science	No. of Periods /Week*	Type of Math**	No. of Periods /Week	Total # Periods /Week
Elementary	1, 2, 3, 4, 5 6	general general general general	3 3 4 4	new new new new	4 4 4 4	26 26 28 28
Preparatory	7, 8, 9	general	4	new	4	30
Secondary Academic	10	biology natural	2 4	new	4	31
	11, 12 (sci. branch)	physics chemistry biology	4 3 2	new	5	31-33
	11, 12 (lit. branch)	general	3	general	3	31-33

* a period is 35-45 minutes
** a change from traditional to new math has been taking place gradually since 1972

Figure 1.1. Time alloted to science and mathematics in the school system in Jordan.

other countries. For example, the approach adopted for chemistry is basically the same as that of the American CHEM-Study program (Pimentel, 1963).

Besides developing the curriculum and textbooks, the Ministry of Education tries to improve chemistry teaching through the efforts of chemistry supervisors associated with the local educational directorates. Those supervisors visit schools and arrange local short seminars, workshops, and summer courses for chemistry teachers.

During the last decade the Royal Scientific Society (RSS), with the cooperation of the Ministry of Education, made some valuable efforts to improve chemistry education. The following are some of those efforts.

1. Establishment of a science education resource center at the RSS which was provided with various modern literature and materials. Chemistry teachers and supervisors can use these resources to be aware of the current developments in chemistry education in the outside world.
2. Arranging inservice courses and seminars to train teachers to improve their practices in teaching specific topics or concepts in newly developed chemistry curricula.
3. Producing some supplementary materials for teachers and some booklets for students and translating into Arabic some outstanding foreign books in school science. "Chemistry, an Investigative Approach" by Cotton et al., an off-shoot of CHEM-Study, has been translated and distributed to chemistry teachers.

The Jordanian Chemical Society, a group of young chemistry teachers, has made some contributions to chemistry teaching at the secondary level.

> With limited financial support they collected equipment and chemicals and worked out all the relevant experiments referred to in the secondary school curriculum. With help from students of chemistry departments at both universities in the East Bank, the society holds periodic exhibitions in schools where students are familiarized with the experimental aspects of chemistry (Nasar, 1980, p. 173).

Many of the difficulties that face chemistry education in Jordan are of the general, administrative type. Limited financial resources have made it difficult for schools to provide effective education in science. Classes are overcrowded by large numbers of students. Many school buildings are not designed for effective classroom instruction and many are poorly equipped. Science labs and other practical facilities sometimes do not exist. The two shift system which is still a general practice in many cities makes the school day too short to provide time for any extracurricular scientific or educational activities.

Professionally, Jordan loses many qualified science teachers and supervisors each year as they go to other Arab countries for better salaries. Some teachers may leave for other professions inside Jordan for the same reason. This loss disturbs the stability of science teachers and requires the appointment of many new teachers every year, increasing the burden of orientation and inservice training programs for new teachers of science.

Under such conditions, teachers and students are striving to get as much science education as possible. High school graduates who pursue their college educations outside Jordan proved, however, to be at least as successful as students of other countries with better educational conditions.*

Due to the limitation of studies on the status of science education in Jordan, the researcher sought other sources of information about science education in the Jordanian high schools. Reports of science supervisors

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*A comment made by Dr. Benson, foreign student advisor at Michigan State University, during a conversation with the researcher in the fall of 1981.

constitute a valuable one. In fact these reports reflect the quality of science education to a great extent. Unfortunately, these reports are not used for the purpose of improving the educational activities in science; rather they are consulted only as an evaluation tool for the supervisors themselves to make decisions concerning teachers' promotions.

In the process of writing a teacher's guide for a chemistry textbook,* reports of science supervisors about chemistry have been reviewed. It was apparent that chemistry education had not gone much beyond reading textbooks and discussing the content. Practical activities suggested in the curriculum were done, at best, as demonstrations by the teacher.

With direct responsibility from the school principal for the teacher's performance and with a follow-up by a science supervisor, the teacher feels responsible to cover all material in the textbook. Under this pressure, s/he does not find time to put emphasis on the development of some scientific skills or processes. The student also knows that s/he will sit for a general national examination, competing in answering questions concerning the facts and theoretical concepts included in the textbook. With these facts in mind, there has been a general attitude among teachers, principals, and supervisors of "why bother about skills and practical experience?"

Science textbooks and teachers' guides indicate the importance of students' achieving a sound level of skills and understanding of science processes. In practice, it was found that the expectations of curriculum developers and textbook writers were seldom fulfilled (Malkawi, 1978). The performance of Jordanian students on the modified Processes of Science Test (POST), however, is not less than the performance of American students on the original POST. Malkawi's study suggested at least three factors to account for this level of

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*Personal experience of the researcher during 1976.

performance and emphasized the need to study these factors to determine how they might affect students' understanding of scientific concepts and processes. These factors are textbooks, classroom instruction, and the evaluation system.

Research on Science Education in Jordan: Status and Priorities

Considering the current status of science education research and practice in Jordan, any good research efforts will be valuable contributions. At the present, the efforts given to research activities at the Ministry of Education level or at the university level are very limited. Both Yarmouk University and the University of Jordan offer a Master's program which requires field research and writing a Master's thesis. The level of this research is very good, but there is no specific line of research which might be related to science education in particular.

Teachers usually have negative images of research and view research findings and procedures as biased and not applicable to their classroom levels. One of the factors which might account for this phenomenon is the fact that some professors and instructors at the university level and in teacher education programs "preach" to teachers to use some educational experiences in their schools. To justify this, teachers are told that research findings indicate that these experiences have been used successfully in country X. Teachers, however, appreciate research which deals with the real problems of their classroom activities. An example of this kind of research is the "action research project" which every trainee at Certification and Inservice Teachers' Training Institute (CITTI) should carry out as part of the training program. Field tutors of CITTI help teachers define a number of their own classroom problems and carry out a research effort to deal with one of these problems or try to solve it. Science supervisors sometimes volunteer to do research in their local districts. However, there is no financial support for this effort, and there is very little chance to publish it.

Defining priorities of research is a task which could be carried out in various ways. One way is a theoretical analysis of the elements of the inputs, process, and outputs of science education, then choosing from these elements those having high priority (Yager, 1978). Another way is using some techniques for obtaining judgments of a large group in an operational way (Butts et al., 1978). The first case relies on opinions and value judgments of individuals or a small group; in the second case a large group of individuals might represent a general trend.

In the case of science education in Jordan, it is suggested that priorities might be better determined through the type of research which aims at understanding the educational practices in school sciences through direct observation. The procedures and techniques of this suggested research should serve as diagnostic devices to deal with the specifics of classroom teaching and learning of a given science program. It is hoped this will define problem areas and, consequently, will suggest further research to tackle these problems.

To deal with teachers' negative images of research, there is a need for research which develops a continuous, two-way flow of information between practicing teachers and researchers. This flow has the potential to modify the conceptions of both sides about each other and to facilitate communication between them (Smith & Berkheimer, 1977).

Research which deals with the specifics of classroom instruction should focus on subject matter and the instructional program as factors having a relatively large degree of structure on teachers' thought and behavior. Most research, unfortunately, has examined classroom teaching with an exclusive focus on observed teaching behaviors: ". . . ignoring the subject matter content and instructional program altogether or has treated them as two of many variables that modify relatively stable teaching patterns" (Smith & Berkheimer, 1977, p. 4).

When the topics of a subject matter are taught, students are expected to learn something. Most of the research of students' learning outcomes in Jordan and elsewhere was an attempt to reflect on how much students know and learn in terms of scores on certain examinations. But the quality of what the individuals know and what they do not know are also important. Any research effort directed to characterize students' learning outcomes will lead to various problem areas about students' conceptions or misconceptions of the scientific knowledge addressed in any specific topic. Defining such problem areas by doing such research is a priority because it is expected to provide a knowledge base to relate research to practice. Failure of students to learn something may be related to a misleading method of presentation in the textbook and/or in classroom instruction or to prior knowledge of students that misdirects the meaning of their learning.

Since the field of research on science education in Jordan is novel, it is assumed that the need is greater for research which "displays scope without very much precision," which is more characteristic of the ethnographic approach than research which "displays precision without very much scope," and is characteristic of the experimental-correctional approach (Roberts, 1981, p. 25).

The study reported here was a case study which has some limitations in being able to generalize from it, but its scope encompassed a wide range of factors playing together on the same stage at the same time. This is always what the classroom is--dynamic and complex.

The Research Problem

The development of curricular materials, teacher education programs, techniques and procedures of evaluation, and other educational services aim basically at the improvement of classroom teaching-learning process. To achieve such basic goal, any decisions related to these services should be built upon valid knowledge of the given situation. Understanding of the real situation of chemistry teaching and learning in Jordan is the starting point of this research.

The content and methodology of this study have tried to meet some of these priorities. It dealt with the subject matter addressed in the program materials, the classroom instructional activities organized by the teacher, and student learning outcomes. It started from students' prior knowledge, then went to the specifics of this knowledge as prescribed in the textbook and teachers' guide to the details of the actual classroom incidents--what was addressed and what was not addressed--and, finally, analyzed what, how, and why students have learned or did not learn.

The present chemistry program in high school was started in 1974. The curriculum and textbooks were developed following the lines of the American CHEM-Study project. The material was chosen, with necessary modifications and adaptations, from the four various versions of that project. Science supervisors, chemistry teachers, and students have various impressions about the program and textbooks. But there was no published research work to evaluation the implementation of this program or its textbooks.

The topic of the subject matter (properties of matter and the particle model) and the grade level (tenth) in this study are both of particular interest. The topic is a major theme of chemistry education at the three secondary grades. It was documented at the Ministry of Education that teachers find difficulty teaching the concepts of this unit (Teachers' Responses on the Questionnaire of Curricula Department, 1981). The researcher himself has written the unit which was investigated in this study. The tenth grade is a critical one as far as science education is concerned because students at the end of that year are expected to choose science, or a science-related discipline, as a career or to leave science with whatever understanding and attitudes that have already developed by that time. These considerations suggest an intensive study of the specifics and particulars of the subject matter and classroom instructional activities and learning outcomes. The potential strength of the ethnographic approach in its ability to deal with such specifics and particulars is fairly obvious (Kilbourn, 1978).

Many of the basic concepts and principles in chemistry were included in the chemistry unit of the natural science program for tenth grade, unit three: "Properties of the Matter and Particle Model." The approach of this unit is summarized as follows: "introducing some experimental observations and using them to develop unifying principles or models." The unit does not have much detail about these experimental observations. This was one of the criticisms directed to this approach. When visiting the classroom, it was found that teachers are treating every observation as a topic for its own sake, exactly as they used to do in the previous chemistry program, and as it was introduced in the traditional textbooks of high school or college chemistry.

To introduce teachers to this new approach, it was a point of emphasis in the teachers' training program held every year since 1972 at the University of Jordan or at the Royal Scientific Society or by the Ministry of Education. The teachers' guide also emphasized this point many times in stating the basic objectives of the chapter and in suggesting the activities and methods of treating various topics.

Teachers, however, find it easier to do the experiment (or just discuss it) and solve the problems without relating them to the major concepts or principles of the lesson. Consequently, students are left without understanding the relevance of the topic under study to the main goal.

Section 1:2 in the textbook, for example, is translated like this:

> "1:2 Laws of chemical composition as a source of information about the structure of the matter" (Abanda, 1974).

Each law is illustrated briefly, using one example in order to see the quantitative relationships in chemical reactions. The definite behavior of chemical elements described through these relationships (laws) is accounted for using the concepts of the molecule and the atom. It is important to see that the proportions involved in the chemical reaction of some elements represent proportions among the atoms of these elements.

Instead of using this approach, teachers have a tendency to deal with each law separately and make sure that students memorize the definition of the law and can solve various problems on it; only at the end do they explain how Dalton's atomic theory was able to interpret these laws.

This change of emphasis and allotted time results in modifying the topics in such a way that the meaning of the program materials is affected. Missing the meaning in science classroom activities by modifying curriculum material creates problems in understanding school science and the attitudes which they develop toward science (Clarkson, 1977). This situation is critical for students in the tenth grade in particular.

The absence of meaningful science instruction has also been recognized by a group of researchers at Michigan State University (Sendelbach, 1980; Anderson & Smith, 1981; Smith, 1980) and by others as well (Gabel et al., 1984). This phenomenon refers to a problem in the quality of science teaching: the lack of relevance of scientific knowledge components which lead to major concepts. It is also an indication of absence of teacher awareness of specific goals and objectives of science programs as intended by the curriculum developers. Shulman and Tamir (1978) referred to a similar observation which is the absence of discussion before or after doing laboratory activities where "much of that work is never consolidated, never brought together, never related to anything else" (p. 13).

Analyzing the origins of this problem through a systematic research effort seems of high priority. One aspect of research that seems appropriate to deal with this problem is to analyze how teachers use the content of the textbook in the classroom. Another aspect of the same importance is to deal with the scientific knowledge of students in order that the teacher will know what the student knows and does not know within the prescribed objectives of the curriculum. These two areas of research were also recognized as being of high priority by the studies on the status of science education in the United States sponsored by the National Science Foundation (Stake, Easely, et al., 1978).

Research on curriculum implementation has pointed out that the degree of success in curriculum development and application depends on the level of understanding of how curriculum materials can be adapted to meet the local classroom conditions. This might account for the shift of research interest toward more emphasis on adaptation and implementation of curriculum materials (Shulman & Tamir, 1978).

Welch (1981) has recognized another shift of concern in the methodology of the educational research. This shift is represented by the growing interest and acceptance of some alternative research strategies which do not impose constraints upon the system under study while the correlational and experimental methods of research are receiving more and more criticism.

It was mentioned earlier that science teachers. staff members at the Jordanian secondary school level, have relatively short tenure due to low salaries. Entering the system each year, there is an expectancy on the part of new teachers of much help and training from local science supervisors. But various responsibilities and heavy demands on science supervisors do not allow them to meet the needs of the individual teachers very effectively. The inservice teacher training program which became available for teachers of elementary and middle school in 1971 through the CITTI proved to be much more effective than the usual services of supervisors. In this model of training, a local field tutor is responsible for a group of teachers from the same field of specialization. The field tutor meets with his/her trainees very often, either during school visits or in a weekly seminar, to discuss specific topics related directly to the classroom teaching-learning activities. A major factor of success is that the field tutor has a chance to examine the subject matter of the textbook and the teacher's planning book before the class in order to make observations during instruction and to intervene to provide needed training for the teacher. Discussions before and after the classroom visit usually deal with the specifics of subject matter. instructional activities, and students' learning difficulties. Using the results of such experiences in many consecutive visits for each teacher provides the field tutor with a wealth of understanding and accounting for what is going on in the classroom. The type of training teachers receive in this way (known in the CITTI program as practical education) provides the teacher with the chance to implement various suggestions and discuss the results of these implementations with the field tutor. It also provides the field tutor with information about the suitability of training activities in various situations with various teachers.

The methodology of this study, called ethnographic, is expected to make basic contributions in many aspects. First, it is a methodology for understanding the complexity of the classroom in a natural educational setting, using various techniques to obtain in-depth knowledge of the activities under study. Second, ethnographic approach provides holistic descriptions and takes into account various contextual factors. It attempts to understand the teaching-learning process in terms of the values, perceptions, and culture of the participants in a natural setting rather than in terms of some preconceived ideas derived from the review of research and studies in areas of different culture and values or derived from pre-structured, experimental situations. Third, the diagnostic characteristic of this approach has indicated various problem areas which need to be further researched in the same way or in any other traditional observational or psychometric approach. Fourth, the results of such a study lend themselves to be utilized readily by practitioners. The direct contact between the research and the teachers provides teachers with various techniques by which they can self-monitor the effects of their own teaching and involve them in an action-research process. Other teachers will also find the study useful in examining their own situations.

To draw on the experience of the work of CITTI, in which the researcher was involved for seven years, and deal with the problems mentioned above, this proposed study aims at understanding and accounting for the actual status of chemistry teaching and learning in a tenth grade classroom and finding out the nature of the interrelationships among three elements: subject matter as presented in the program material, actual classroom instruction, and students' learning outcomes.

The Research Questions

The purpose of this study was to describe and interpret the classroom teaching-learning process in a tenth grade science classroom and to identify some of the factors associated with science instruction. The design of the study allowed for a wide range of observations and procedures of data collection, implying various perspectives, to focus on actions, interactions, activities, and beliefs of the classroom participants. Research questions for this purpose came in a general form and were characterized by an open-ended nature to allow for soliciting comprehensive descriptions and employing diverse perspectives of classroom instruction, its antecedents, and its consequences.

The study tried to answer the following questions.

1. What is the structure of unit three, "Properties of Matter and the Particle Model," of the Natural Science Course (NSC) of the tenth grade, as presented in the textbook and the teachers' guide?
2. What is the nature of actual classroom instruction?
   - 2.1 How does the teacher use the course material in her instruction?
   - 2.2 How does the teacher address the scientific objectives of the course?
   - 2.3 What do the activities of classroom instruction mean to the teacher and to the students?
3. What is the nature of student learning outcomes?
   - 3.1 What accounts for the differences between intended learning outcomes and achieved learning outcomes?
4. To what extent do the teacher and students share the meanings of knowledge addressed in the unit?

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3. What is the nature of student learning outcomes?
   - 3.1 What accounts for the differences between intended learning outcomes and achieved learning outcomes?
4. To what extent do the teacher and students share the meanings of knowledge addressed in the unit?

5. How does the teaching-learning process in the particular classroom under study relate to the situation of other classrooms in other schools?

The following chapter presents a review of literature related to the present study. Literature of three areas is reviewed briefly. The present status and future trends of chemistry education are reviewed first, then the basic features of the ethnographic approach which is the research methodology used in this study are presented. Finally, some aspects of the research of teaching and learning science are presented, especially the research which focuses on relationships among curriculum materials, teaching activities, and student learning, and which employs case studies and students' conceptual learning.

CHAPTER II

REVIEW OF LITERATURE

Overview of the Chapter

The purpose of this chapter was to present a picture of three main areas which relate to the content and methodology of this study. These three areas are (a) the current status and future trends of chemistry education, (b) the ethnographic approach as the research methodology adopted for understanding classroom teaching and lerning, and (c) research on teaching and learning science which focuses on how subject matter is presented in curriculum materials, taught by teachers, and learned by students, with special emphasis being given to case studies of science instruction.

The content of classroom teaching and learning in this study comprised the first three chapters of unit three of the natural science course for tenth grade students in Jordan. This unit, "Properties of Matter and the Particulate Model," was originally part of the Jordanian high school chemistry program developed in 1970. But it was incorporated in the natural sciences program in addition to other topics related to physics, astronomy, geology, and meteorology. The unit deals with concepts such as molecule, atom, mole, chemical reaction, electron configuration, periodicity of chemical properties, solution, chemical bond, etc., which are considered to be fundamental concepts in any school chemistry course. The development of our knowledge related to these concepts is also considered an important example of how scientific theory grows and is a chance for students to understand some aspects of the nature of science. An overview of literature concerning teaching and learning these concepts will be helpful to relate the findings of this case study to what is thought to be the situation in the larger context of the educational world.

The use of ethnographic techniques for studying educational setting has been growing recently. But ethnography is still unfamiliar in Jordan. Some aspects of this tradition have been presented in this chapter, especially with reference to its use in studying teaching and learning in science classrooms.

Finally, several studies were chosen to be reviewed briefly. Those studies investigated the quality of the relationship among curriculum materials, teaching activities, and student learning by conducting case studies of relatively small numbers of subjects. A subcategory of this kind of research might be the growing trend in investigating the nature of students' conceptual development.

Many researchers met in 1982 and 1983 in two conferences to report and discuss students' scientific conceptions. The results of these discussions were summarized. A general summary was presented at the end of the chapter.

Chemistry Education: Present Status and Future Trends

Chemistry as a science plays an essential part in producing educated citizens in society, citizens who are sensitive to possible effects of the activities of scientists and technologists on their welfare, both now and in the future. In this respect, if chemistry is taught adequately, it stimulates an intellectual pleasure, gives variety of experiences in posing and solving problems, and helps people to make sense of their surroundings. Because the lives of all people are so intimately tied to chemical reactions, both within their bodies and in the environment around them, chemistry can have special significance in helping students know themselves and the world in which they live.

In addition to this role of chemistry in general education, human society needs the service of chemists in large numbers, larger than for any other science discipline, in order to achieve and maintain reasonable standards of living (Coulson, 1974). For this purpose, the school should be prepared to attract the needed number of individuals for a profession in chemistry.

Among other science disciplines, chemical education has received considerable attention and support in the post-Sputnik era, not just in the United States, but in many other countries as well. New courses and program materials have been developed in the USA, Europe, and many of the Third World countries. Laboratory equipment and supplies have been provided to school. Various teacher education programs and workshops have been conducted. Research on chemical education, especially in the United States, however, indicates inconsistent results concerning the effectiveness of these new courses, materials, and techniques. Therefore, some questions have been raised concerning the accountability and pay off of the large amount of money which has been spent in this regard.

The reform movement in science education in the 1960s was considered a revolution on a broad educational front, involving not only the curriculum and its organization, but a change in the entire philosophy about the purposes and values of education (Hurd, 1970). "New" chemistry courses, for example, were believed to reflect the structure of the discipline itself. That is why the chemical bond approach (CBA) and the chemical education material study (CHEMS) were different. The powerful pressure group of scientists who produced CBA were mainly physical chemists in universities. Consequently, their focus was molecular architecture, and the entire course was built around the bonding concept which they perceived as the central idea of chemistry. CHEMS, on the other hand, was designed to reflect chemistry from the chemist's point of view. CHEMS director stated:

> A chemist is a person who makes experimental observations and then interprets them in terms of atoms and molecules and their behavior. The CHEM Study course is planned to allow even first year students to utilize the same approach and conceptual treatment (Campbell, 1971, p. 88).

In addition to its emphasis on the importance of the experiment, CHEMS continually stressed the "beautiful structure" of chemistry by encouraging students to realize " . . . that by observing the results of experiments and their regularities, one may come to recognize and identify the unifying principles which are the framework and structure of chemistry" (Seaberg & Ridgeway, 1980, p. 10).

Developers of the "new" chemistry programs had an ambition of providing a quality of chemistry education in which students would be able to achieve better understanding of the nature of science and develop a positive attitude toward science as well as competence in using scientific processes and skills. For this purpose the chemistry programs included various materials: textbooks, lab manuals, special lab equipment, films, and many supplementary booklets, activities, and tests. The objectives of chemistry teaching incorporated the three domains of knowledge: cognitive content, attitudes, and skills. Scientific facts were not considered important by themselves; the principles upon which these facts rest were given much more importance. The textbook is not the final authority for developing these principles; the empirical data derived from laboratory work by students are the basis for this development. The direct involvement of students in doing science, not the knowledge of teachers, is the key for student learning.

The authors of "Chemistry, an Investigative Approach," an off-shoot of CHEMS, tell students in the preface of their textbook:

> You will be engaged in scientific activity in fundamentally the same way as any scientist is engaged. You will become a scientist as you study chemistry.
>
> Great emphasis is placed on experimentation and observation as the basis for all knowledge of chemistry. The unifying principles of the subject are developed in a logical way with laboratory work providing a basis for that development (Cotton et al., 1973, p. v).

This view does not necessarily appeal to many students who are motivated to continue careers in science. However, students can learn science concepts without being scientists. They can also understand scientific laws and principles without being in the laboratory using the discovery method.

It was expected that these new materials would attract more students to chemistry classes and help them achieve the above mentioned quality of learning. But the actual situation as seen in the findings of many studies was far below the expectations of the curriculum developers and represents an unsatisfactory state of affairs, especially when compared with the great expenditures and energetic efforts made to achieve the intended changes (Welch, 1979; National Science Foundation and Department of Education, 1980).

Chemistry enrollments, however, showed a small percentage of gain in the 1960s and early 1970s. Since 1971 the percentage of students taking chemistry appears to have declined slightly. In 1977, only 19% of high school students have taken chemistry (Ware, 1980). Many schools moved quickly to use CHEMS in the 1960s. Thirty percent of students studying chemistry were using CHEMS materials in early 1971. The use of CHEMS, as well as other NSF-developed science programs during the 1970s, has shown a continuous decline (NSF, 1980). In 1974 state reports and surveys indicate that 50% of students studying chemistry were using Modern Chemistry (Holt), the text used by most students of chemistry during the 1950s (Helgeson et al., 1977). Less than two percent of students studying chemistry were using CBA in 1970-71 and 1976-77 (Welch, 1979).

In the way it is currently taught in the United States, chemistry is a self-selective course. Students who select chemistry usually have above average IQs, college-bound futures, and scientific-type career goals. Students taking all types of chemistry courses constitute approximately 40% of all high school graduates in the United States (Bridgham, 1973).

In response to a variety of concerns, the National Science Foundation initiated a major effort in 1975 to examine the status of pre-college science, mathematics, and social studies education. Ronald Anderson (1980) summarized the significant findings about the status of science education as reflected in the NSF series of studies in four points.

1. Science education is not a significant part of general education.
2. There is an obvious, extensive, and almost exclusive attention to fundamental knowledge, with a very few isolated instances of attention to other goals.
3. The curriculum is textbook-bound, and the text is the authority and source of information.
4. The teacher plays the key role, and the educational experience of students in the classroom is a function of who the teacher is.

Many researchers suggest that high school students face many difficulties in learning science. These difficulties, at least in part, are cognitive in nature. The existing instructional materials, on the other hand, offer teachers very little help in overcoming these obstacles to learning and understanding. Arons (1981) believes " . . . that deeper insights leading to improvement of instruction can come from careful observation of the details of student cognitive processes" (p. 166).

During the past half-century, hundreds of research studies have been conducted within a framework of Piaget's developmental theory. Science and mathematics education had a good share of these studies. Studies in this tradition claimed that most chemistry concepts are too difficult to be understood by a large proportion of high school students because those students did not acquire the required "cognitive operations" for such understanding. Kass and Wheeler (1979) have found that at least one-third of high school chemistry students may be classified as "concrete thinkers and, hence, according to Piagetian theory, will likely have difficulty in coping with some of the logical requirements of the concepts presented" (p. 2).

Patricia Smith (1978) cited many investigations which show that approximately 50% of high school students are unable to use formal thought processes. Most of the questions of general examinations in chemistry, such as those of CHEMS, assume the ability to use formal operational thought processes. Most chemistry concepts are abstract in their nature, and many students are unable to understand them unless appropriate strategies in teaching were used. Even in solving problems related to these concepts, students can do the problem if it is set nicely without understanding of a concept like the mole. Memorization of an algorithm which can be used to solve the problem " . . . fools both teacher and student into thinking that the lesson has been learned" (p. 115).

Critics of studies conducted within the framework of Piagetian educational psychology refer to a source of confusion in interpreting the findings of these studies. For example, Novak (1978) indicated in this regard that

> Much of the confusion in educational work based on Piaget's studies has derived from extrapolating ideas from his developmental psychology to the interpretation of learning events and to the design of instruction constrained by parameters of Piaget's developmental theory (p. 10).

This researcher holds a more optimistic view of human nature than the pessimistic one that can be inferred from the findings of Piaget's studies. This view depends on the fact that most people of various ages can perform extremely well in abstract thinking when they are equipped with the required and relevant framework of concepts. If the instructional design can provide an adequate organization of educational experiences which facilitate new learning, then students might be able to learn those abstract chemistry concepts that students of Kass and Wheeler and Smith were not able to learn.

A number of studies were carried out during the late 1970s concerning students' misconceptions in chemistry (Gabel et al., 1984; Kass & Wheeler, 1979; Smith, 1978). Many of the major concepts usually presented in high school chemistry are found difficult for students to comprehend and integrate with another into a coherent understanding. Among these are the mole, chemical equation, rate of chemical reaction, electronic structure of the atom, concepts of thermodynamics, and many others.

The results of the national assessments of science indicate that most students at ages 13 and 17 are most deficient in just those higher order mental skills which are components of reflective thinking and problem solving ability. The methods and outcomes so frequently recommended by science educators are not often found in actual instructional practice in schools or as an actual outcome by students (Champagne & Klopfer, 1981).

There have been many recent reports concerning the declining skills of entering college freshmen. Groby at Washington State University has gone to great length to document this decline for entering chemistry students at that school. Brooke (1978) believes that this observation reflects a national phenomenon: "College chemistry departments have been accommodating the decline for some years . . . . Our society is less reading-oriented and less homework-oriented than it was 15 years ago" (p. 90).

Bent (1980) indicated that most chemistry courses and classes these days attempt to do too much too soon. There is too much telling, too little showing.

They do not reflect the real nature of science. While we tell students that science is not dogmatic and is not guessing, we provide them with texts full of "telling"; we test them using multiple choice questions and allow very limited time to use in laboratories. Chemical education in schools today emphasize the products and ends of science (facts and theories) over the processes and means of science. It " . . . emphasizes better things for better living . . . over better ways to better things" (p. 30).

At the International Conference on New Directions in the Chemistry Curriculum held in June 1978 at Ontario, the participants expressed their feelings about the widespread negative attitude toward the subject of chemistry. They also referred to the "down-grading" of experiments as of lower significance than theory (Benfey, 1980).

The case for school science laboratories is no longer as self evident as it once seemed. Since the late 1970s, money for education has become scarce, and educational priorities have been reevaluated. Some research findings indicate that some students find laboratory to be a waste of time and merely a means of slowing their pursuit of new theories and concepts (Bates, 1978).

A very experienced chemistry teacher in a very prestigious town who is the head of the science department in his school and who participated in the early development of CBA and PSSC does not view the role of laboratory as an important thing.*

For chemical education and science education in general, the 1970s period was described by Fernelius (1976) as the age of the "breakdown of confidence." When NSF was established, the public had confidence in science, scientists and scientific establishment. But the public have lost their faith in science and in

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*Personal observation of the author in a visit to that school in Winter 1980.

science education. In the public's view, science was the solution for problems of society; science is now thought of as the reason for many difficult problems facing society. Education was the institution of preparing the scientifically educated citizens; education is now viewed as producing high school young people lacking the "basic skills"!

One of the problems facing chemical education in the United States is the lack of experience for those who enter the profession without adequate preparation in it in college and the lack of inservice teacher education programs, especially after the vacuum created in the field by the termination of NSF institutes and conferences.

New Trends in Chemical Education

Curriculum development has been subject to contemporary societal pressure. A new curriculum usually tries to address new demands. In the late 1950s, the shock of Russian technological progess presented a challenge for the United states to provide an adequate supply of stilled scientists and technologists. CHEMS and CBA came as a result of this pressure with a heavy emphasis on producing more and better trained chemists. During the 1970s, new types of pressure were developed; energy crises and environmental crises turned many curriculum developers toward programs which addressed the new societal demands and brought into being many chemistry programs which put an emphasis on the relevance of the program to daily life problems and issues.

Many courses in chemistry were developed during the last few years with an emphasis on environmental problems. This major emphasis has gradually shifted to a broader concern about the world's resources of air, water, energy, minerals, and food. There is also an emphasis on chemical education related to health (Kolb & Taylor, 1981). To make chemistry classes more interesting and at the same time help students keep their grades at a reasonable level, Arnold (1980) used a special technique in his teaching called "research project and two-level curriculum." To keep chemistry relevant to societal problems, Kolb and Taylor (1980) developed a course in chemistry and civilization. The basic material of this course is made up of current "squib" items from the printed media. In addition, there is a tendency to provide chemistry courses at different levels to match corresponding levels of students' abilities and also to match the requirements of some specific fields of specialization. Newman (1980) has developed two different courses for the superior students.

Patricia Smith (1978) developed a high school chemistry course to promote formal reasoning by increasing opportunities for self-regulation and to increase students' understanding of chemical concepts by making the instruction relevant to students' developmental levels. She used the SCIS-learning cycle--exploration, invention, and discovery--in her program.

To face the "back to basics" movement, Waterman (1980) developed his chemistry course to emphasize the mastery of three basic objectives: to communicate effectively, to demonstrate a working knowledge of mathematics, and to apply acquired knowledge in thinking and solving problems. He believes that chemistry teachers have unique opportunities to develop these skills, and in this process a great deal of chemistry can be taught as well.

High school chemistry teachers participating in the master program in chemical education in several universities in the United Kingdom have made significant contributions to the development of chemical education as an academic discipline. The emphasis of this program is the research of problems or the developments of teaching and learning ideas related directly to the work of the teacher in his/her own school (Hudson, 1980). This trend is an attempt to fill the gap between educational research and practice which is very wide and very unfortunate as well. Cope and Gray (1979) described some important experiences in this regard.

To emphasize the importance of chemical education as a part of general education in Italy, Paoloni (1979) proposed a culture-based approach for students aged 13-18. In this proposal, chemistry was introduced as a logical method for the analysis of the nature of matter without using the concepts related to the electronic structure of the atoms and with elimination of the distinction between the organic and inorganic. This methodology:

> . . . allows a consistent presentation of the concepts of chemistry used for more than a century for the study of matter, and it allows pointing out clearly their shortcomings and, hence, to prepare the ground for an approach based on some concepts of elementary quantum mechanics (p. 375).

There is an increasing tendency to express the need to include value-based issues in chemical education (Brooke, 1980). The same need is also applied to the history of chemistry. There is no doubt that including history of chemistry in curriculum reveals to the students that chemistry is an integral part of human activity. It also helps to recognize that the subject is a dynamic one. Ihde (1980) refers to the "flow of research papers dealing with all aspects of history of chemistry" as a facilitating factor of developing courses in the history of chemistry with considerable accuracy. He also indicates the importance of this field in developing an interest in the subject, revealing an understanding of the nature of scientific enterprise and fully appreciating that ". . . the best wisdom of those at the frontiers of the science represents merely a transient state in understanding of the subject" (p. 12).

There is a real need for chemistry courses to broaden students' intellectual horizons and enable them to enjoy more fully our cultural environment. We need to enjoy our lives with greater harmony with the world around us. Both the style and content of chemical curricula are worthy of continual attention and modification. Students need to be aware of the current activities in chemistry and the goals that motivate those activities (Hammond, 1979). The main theme of any course is built around what was known and understood at that time. But it should be possible to "weave in a pattern of the unfolding field" by choosing carefully some examples of aspects that we do not yet understand or things that we cannot do.

That students usually respond better to specific problems has been the subject of considerable investigation. Choosing such aspects as our goals helps in teaching methodologies which seem to work in solving these problems. This does not mean that generating some awareness and interest in more global problems should be excluded.

The researcher tends to agree with Patricia Smith (1978) in her idea that:

> . . . secondary chemistry instruction must move away from an encyclopediac coverage of the field and toward teaching things of greater conceptual understanding. The large majority of high school chemistry students do not major in chemistry. Some do not go to college. For these students, the opportunity to mature their thinking style and become acquainted with the way that scientists work is infinitely more important than detailed knowledge of theory (Smith, 1978, p. 118).

Ethnography: Methodology for Understanding

Science education researchers have been using typical research methodologies for almost one century. The dominant research paradigm was based on the natural science model (Patton, 1975). It was argued also that this research paradigm tried to be rooted in or rationalized by reference to some form of psychological theories of learning and motivation (Shulman, 1970). This research paradigm, however, has been exposed recently to many attacks. Some researchers describe the methods of this paradigm as becoming "increasingly tired and tiresome" (Roberts & Russell, 1975) or "cumbersome and inadequate" (Hamilton, 1977). Other researchers recognize that these experimental, correlational methods ". . . provide little information about physical, social, temporal contexts within which events occur and which help give them meaning" (Power, 1976, p. 5). This research also uses pre-set category systems which describe the frequency of events in the classroom but do not describe the quality of these events (Kilbourn, 1978).

Many alternatives have been introduced by the opponents of the dominant research paradigm. These alternatives are based usually on some metatheoretical assumptions different from those of the dominant one. The differences between the two paradigms also exist at the operational level. Each alternative has a point of emphasis and, consequently, was given a special name accordingly. Among the various names are contextual, descriptive, qualitative, ecological, ethnographic, holistic, anthropological, phenomenological, constructive, naturalistic, illuminative, etc. Although there might be some differences among these names, there is a common tendency among most of them to do intensive study of the educational setting without imposing any constraints on the situation. The term which is used the most is the ethnographic approach.

There has been much controversy during the last few years concerning the relative merits of each of the traditional and ethnographic approaches. Recently some researchers and reviewers of research recognized the need for the two. After examining the value of both alternative forms of inquiry, Welch (1981) concluded:

> Each has a place in educational research and each should be accepted by the research community as capable of increasing knowledge and understanding. It is important, however, to recognize their strengths and limitations so that informed choices can be made in choosing one or the other of these inquiry paradigms (p. 15).

Douglas Roberts (1981), likewise, analyzed the different metaphysical commitments inherent in each of two approaches of research in science education; then he tried to ". . . develop a systematic account of the differences between quantitate and qualitative research, which in turn enables one to conceptualize their complementarity and importance of both to science education research community" (p. 1).

Since the two approaches of research complement each other, both are valid; the choice of using one approach should depend on the research problems, the types of questions to be asked, and the kinds of decisions to be made as a result of the research.

It was decided earlier that ethnographic approach would be chosen since it appears to be the tool most helpful in addressing the questions of the study. A brief discussion follows about the basic features of this methodology, its assumptions, procedures, and applications in science education.

The use of ethnographic techniques for studying educational settings is growing. "Ethnographic" refers to an anthropological method because historically it has been associated with that particular discipline, but is is now described as an alternative paradigm to the dominant correlational experimental approach. This alternative paradigm was labeled variously as field work; case study; naturalistic description; descriptive, constructivist, or ecological approaches, etc. (Erickson, 1978).

The major question in an ethnographic study is, What are people in a given setting doing, and why are they doing it? To answer this question, the ethnographic researcher tries to describe in detail what is going on in that setting; then s/he analyzes that description to make sense of the data collected and to test his/her perceptions and sense-making against the persepectives of the native participants.

Ethnographic approach aims at refocusing educational research on the complexity of the school phenomenon which needs to be explained by making extensive descriptive and interpretive efforts.

It is important to understand that ethnographic approach represents fundamentally different claims about the nature of human behavior and ways of coming to understand it. These claims could be represented by the assumptions of the ethnographic approach. This approach considers the subjects being studied as "knowing beings" and assumes that the knowledge they possess has important consequences for how behaviors or actions are interpreted. A second assumption is that complex behaviors like teaching and learning might be best understood as being constructed purposively by teachers and pupils themselves and cannot be adequately studied without accounting for meaning and purposes. A third assumption is that a human being has a highly developed capacity for developing knowledge by organizing complexity, attending to the meanings of complex communication, and having individuals take on complex social roles (Magoon, 1977).

Ethnographers claim that if one hopes to generalize research findings to the everyday world, where most human events occur, then the research must be conducted in settings similar to those that the researchers hope to generalize about. Divergent findings of extensive research demonstrate the importance of the influence of the setting when the same phenomenon is studied in laboratory and in the field. School exerts many powerful forces on participant behavior, so educational ethnographers warn that if one wants to generalize research findings to schools, then the research is best conducted within school settings where all these forces are intact.

Available theories of learning and teaching should be related to a realistic view of the classroom in order that meaningful hypotheses can be formulated about teaching process and its effects. To accomplish this, it is important to make distinction between traditional educational research hypotheses testing, and the generation of such hypotheses as a result of ethnographic accounts for how a particular situation can be explained within the framework of a more general theory. Observations give the researcher access to an immense number of sequences of events. As s/he tries to shape these into empirical and conceptual order, hypotheses arise (Magoon, 1977). The rule for generation of theory is not to have any pre-set or valued hypotheses, but maintain a sensitivity to all theoretical relevances among the data.

In this connection, Rist (1977) viewed the means by which knowledge and understanding are developed as an inductive analysis and stated that theory begins with an extrapolating from "grounded events." The ethnographic researcher "begins not with models, hypotheses or theorems, but rather with understandings of frequent minute episodes or interactions that are examined for broader patterns and processes" (p. 44).

In an attempt to foster large-scale educational reforms, fieldwork has thrown light on some of the blind spots of previous research, namely neglect of the social and cultural dynamics of schooling. Through consideration of how educational activities fit into (or conflict with) the various social roles of actors in education (parents, students, teachers, etc.), fieldwork techniques have offered a way of identifying some of the obstacles to reform that were missed before. The methodology of fieldwork can uncover a variety of information which may be lost to quantitative methods of inquiry (Schwille & Porter, 1976).

The ethnographic approach has gained a wide acceptance in psychology and sociology within the last two decades, and it is probable that it will rapidly gain such acceptance in educational research in the decade ahead. Recently, ethnographic research has become of major interest in the United States at the federal level. NIE sponsored two large projects (CBTSS, FSUDS) using fieldwork as a vehicle for research to improve our general knowledge of schooling (Schwille & Porter, 1976). NSF sponsored 11 case studies, conducted throughout the USA by specialized educational researchers, to apply ethnography as a methodology to understand the status of science education and as a result to draw some desirable future direction.

Doyle (1979) viewed this trend of research on teaching, one he calls the ecological model, as an "analytical framework for understanding how classrooms work." He distinguished among three important aspects in which such an ecological understanding will provide help. First, it is especially useful for individual teachers to interpret problems and to generate solutions to meet practical contingencies in specific classrooms. Second, it assists curriculum planners in designing programs that account for the demands of classroom environment. Third, it provides a basis for identifying points for intervention into the classroom system and for anticipating the consequences of changing curriculum.

The methods used in ethnographic research can be rigorous and systematic as those of other approaches. It is a vital and viable tradition which is constantly in the process of being evaluated and refined. One of the most important ideas behind this approach is that there is no one right method; the method should match the study. The special technique used in this research can be coordinated with other methods into an excellent research design that could elicit information not accessible to researchers using more quantitative techniques.

After using an ethnographic approach to study some parameters of teacher effectiveness, Scoot (1978) concluded that, although this methodology is difficult, time consuming, and expensive, it proved to be very fruitful and yields data that cannot be obtained using other techniques; and once these data are collected, they can be used again and again as new questions arise.

Both Patton (1975) and Rist (1977) cited the contribution of Scriven (1972) in discussing the objectivity and subjectivity in educational research. The terms objective and subjective are always held to be contrasting; they are used mainly to reflect the quality of the evidence where subjective means unreliable, bias, or matter or opinion, and objective means reliable, factual, and confirmable. It is precisely to avoid the fate of unreliable, biased, or opinionated data that reliability is stressed in quantitative approaches. But for the same goal, qualitative researchers get reliability through personalized, intimate understandings of social phenomena, stressing "close in" observations to achieve factual, reliable, and confirmable data. The quantitative researcher would pursue confirmation through the use of a large number of subjects, while the ethnographer would seek the same goal using large numbers of incidents or events in an intensive case study of a small group or even one individual.

Ethnography as a holistic approach to understanding schooling can produce an explanatory model of what goes on in a classroom (Lutz, 1981). When the classroom is observed as a cultural system using the tools of ethnography in collecting data and seeking for meaningful patterns of events and behaviors, the ethnographer can document how the "natives" of the classroom interpret those events and behaviors. The researcher also has his/her own interpretation. Lutz called the natives' perspective and the researcher's perspective a representational model and an operational model, respectively. The interface of those two models produces what Lutz called explanatory model.

Ethnographic research depends on the ability of the researcher to make him/herself a sensitive research instrument by transcending his/her own perspective and becoming acquainted with the perspectives of those being studied (Wilson, 1977). Seeing, rather than measuring, was the activity of the project of case studies in science education. Wayne Welch summarized his fieldwork methodology in Case Study-5 as follows:

> The data were obtained from six different sources: (1) semi-structured interviews where notes were taken concurrently, (2) in-class observations using a class observation form, (3) school documents such as daily bulletins, enrollment sheets, and the school yearbook, (4) meetings I participated in or attended, (5) informal discussions in the hall, lunch room, or teachers' lounge, and (6) informal perceptions from just moving around the building (Stake & Easley, 1978, p. 5:18).

One of the primary ways of increasing validity is by triangulation and cross-checking. The triangulation in the case studies in science education occurred both within and across case studies. The field observers sought out informants having different positions, roles, experiences, attitudes, and goals in order to check the perceived regularity of a phenomenon. The researchers themselves observed and analyzed documents. Their findings were reviewed by site visit teams, site coordinators, and on-site educators. All provided additional views as well as confirmation or disconfirmation of particulars. Also, a great deal of information was obtained from a large population of teachers, principals, supervisors, and parents throughout the USA by means of a general survey as part of the same project of CSSE (Stake & Easley, 1978, p. 18:2).

Case study approach has been degraded by several major methodologists in the past. The well-known Campbell and Stanley (1963) description of experimental and quasi-experimental design for research in teaching pointed out that the one-shot case study which they called the X-O design has a "total absence of control as to be of almost no scientific value." Many opponents of the case study approach still quote this position of Campbell, perhaps unaware of the fact that he has retreated from this earlier position and admitted that such studies had "regularly contradicted" his "prior expectations" and that they probe and test power which he "had not allowed for." He stated clearly, "If we are to be truly scientific, we must reestablish this qualitative grounding of the quantitative in action research" (Campbell, 1974, p. 30).

The number of researchers, evaluators, and policy makers in various fields and different countries who have been urging the use of case study techniques is growing significantly. The field of educational research now is familiar with such terms as educational ethnography, school ethnography, classroom ethnography, and microethnography, which refer to case studies involving a school system, one classroom, one teacher, one lesson, or even one student.

Although case studies have been described repeatedly in recent literature as approaches of using qualitative types of evidence, they can, in fact, use either qualitative or quantitative techniques, or both at the same time (Yin, 1982).

A case study is not necessarily an ethnography. Ethnographic methods of data collection can be used in a case study, but other methods of systematic observation systems can also be used in a case study. The case study is a research strategy whose distinguishing characteristic is its "attempts to examine . . . a contemporary phenomenon in its real-life context" (Yin, 1982, p. 169).

Because teaching is an interactive complex of events, ethnographic methods were used to study the instructional process as it occurred naturally in a college science classroom to determine specifically how and why a distinguished professor was successful in accomplishing his teaching goals. A detailed descriptive account of teacher-student interactions was provided as well as documentation of the professor and his students' perspectives. Colleen Cooper (1979, 1983) who was the participant observer in this study found that the professor used a storytelling technique to share his knowledge and to involve his students in the learning activities. The research in this study was viewed as interactive, inductive, and developmental procesess which involved five research activities: posing broad questions, collecting data, developing tentative hypotheses, confirming or disconfirming hypotheses, and developing more specific questions.

A year-long ethnographic study of the interrelationships of three instructors of science in a community college and their students in a laboratory setting was conducted by Dodge (1982). Various qualitative methods including participant observation, surveys, interviews, videotapes of lab sessions, and review of documents were used. The study suggested that the teacher role is a function of transaction among many extrinsic factors such as curriculum, institution, students, and the physical arrangement and intrinsic factors such as personality, values, and attitudes. The teacher's perception of his/her role in managing the learning environment determined the amount and type of instruction in a laboratory setting.

Related Research on Teaching and Learning Science

It would be a very difficult task to review research on teaching and learning science in general here. This kind of research is included in many summaries and review of research in science education such as the yearly summaries of research published in the Science Education and the yearly abstracts of papers presented for the annual meeting of the National Association of Research in Science Teaching (NARST). There are also reviews of certain areas or types of research such as reviews of science classroom interaction research (Balzer et al., 1973; Power, 1977), review of studies related to the concept development in adolescent science students (Driver & Easley, 1978), and review of classroom observational studies in science education (Anderson, 1979).

Researchers in science education differed greatly from each other in the focus, level, and approach they used in their studies. They are also influenced by the dominant trends in the practice of education and educational research in general. The major focus of research in the 1960s, for example, was on curriculum development. This focus has changed in the 1970s into teacher effectiveness (Brophy, 1980). In the last few years, the number of studies dealing with conceptual change and student learning of scientific concepts is growing.

Writings of philosophers of science, especially those identified as logical empiricists, and of the "new" philosophers of science such as Kuhn, Toulmin, and Hanson indicate the importance of the conceptual knowledge shared by the community of scholars and its influence on scientific achievements. Information processing psychologists, likewise, are concerned with the influence of the conceptual knowledge held by a person on that person's behavior. Although this conceptual content which is to be taught in the classroom is important as seen by those philosophers of science and psychologists, this content has not received the attention of educational researchers that has been given to other commonplaces of education, the teacher, the learner, and the milieu (Stewart et al., 1982). This neglect was noticed two decades ago by Schwab (1964): "Only the subject matter among the four has been relegated to the position of a good wife: taken as familiar, fixed, and at the hand when wanted" (p. 4). Only recently the content or the subject matter became the focus of interest in some research efforts. Similar growing interest and awareness of the value of case study techniques and ethnographic observations among science education researchers, brought the subject matter in a science classroom to be the focus of investigation in research literature which will be reviewed briefly.

Smith and Sendelbach (1980, 1982) carried out a program of research to investigate the teaching-learning process in a sixth grade classroom using an activity-based science program. Four focal points for analysis in this research represent the components of the model of research developed in this study. These components are program materials, teachers' intentions, classroom instruction, and student learning. Smith and Sendelbach developed various procedures, instruments, and protocols to analyze each of these components. The key point of this investigation was the examination of what actually was taking place in the classroom and understanding how program materials and teachers' intentions influence what happens.

In his dissertation, Sendelbach (1980) has used a theoretical framework for the research model proposed by Stake (1974). The model consists of two columns referring to what is intended and what is observed in the teaching-learning process. Each column has three levels referring to the three stages of the teaching-learning process, the antecedents, the transactions, and the outcomes. Stake proposed to investigate the contingencies between the levels of each column and congruence between corresponding levels of both columns. The model is illustrated in Figure 2-1. Sendelbach made the focus of his study on the first two levels of both columns.

General findings of his study reveal the teachers' orientation is related to a segmented, conceptual framework which is significantly different from the holistic approach of the literal program. The major concern of the teacher in this study was to get her students to be engaged in manipulating materials and to meet the classroom management requirements. Intended learning outcomes were not often developed by students.

This study picked up on what Sendelbach has done and used the same theoretical framework proposed by Stake (Figure 2-1), to investigate the dependency of the features of any level on features of other levels, and the extent to which the observed levels are congruent with the intended ones.

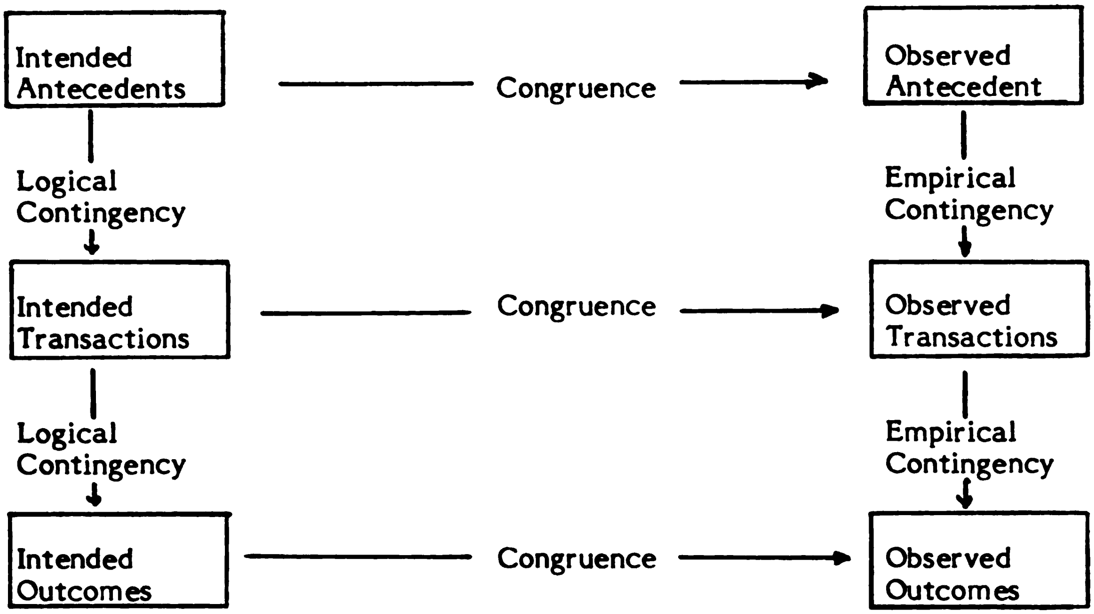

Figure 2-1. A representation of the processing of descriptive data (Stake, 1974).

Several case studies were conducted at Michigan State University to investigate the factors that limit the quality of science instruction at the upper elementary level (Eaton et al., 1983; Smith & Anderson, 1983; Slinger et al., 1983; Anderson & Smith, 1984; Smith & Anderson, 1984). The main objectives of these studies were to analyze existing patterns in teachers' use of science program materials and their effect on instruction as well as to analyze the effect of an environmental intervention to promote a mutual adaptation process which involves modification of both teachers' guides and teachers' planning processes. Eclectic methodology and perspectives were used in these case studies where school ethnography had been a major source. Each case study dealt with one or two teachers and a small number of students. Teachers observed were known to be "excellent" or "good" experienced teachers. Several interesting findings were reported. The textbook and teachers' guide were found to be inadequate in addressing the scientific concepts in a way which takes into consideration the misconceptions usually held by students. Teachers were not able to be appropriately prepared to deal with these misconceptions by relying on the textbook and the teachers' guide. Teachers were interested in getting students to arrive at what is believed to be the correct answer without treating the incorrect answers in diagnosing the students' misconceptions (Slinger, 1983). Even when the teacher became aware of these misconceptions in another study (Smith & Anderson, 1983), she was not successful in helping her students replace these misconceptions with what she intended them to learn. This disappointing result was seen in light of the differences in views held by the teacher and the curriculum developer about student learning and the nature of science. Teachers' guides failed to communicate a view of student learning and instructional strategy to the teacher which can help her design an adequate strategy to promote student learning.

To be able to capture the quality of relationships among teachers' intentions, program materials, classroom teaching, and student outcomes, Kilbourn (1982) undertook a qualitative analysis of one biology lesson in a ninth grade classroom. Kilbourn argued that:

> This qualitative analysis arising from the participant observation of a beginning teacher has nurtured the development of a way of looking at science teaching that respects both the reality of classroom events and some of our more treasured epistimological goals for science teaching (p. 686).

The purpose of introducing the topic in the textbook was to enable students to develop some understanding of scientific process. This goal was also included in the teachers' plan for teaching. After analyzing the topic of the lesson as presented in the text and the teaching episode of that lesson, the researcher found that both of them had fallen short of dealing adequately with the topic to achieve the intended goal. The "salient content" in the text was missing, and the teacher did not have an active attempt to provide that content or to help the students either to be aware of the intellectual skills they were using or to see what aspects of the investigation were analogous to scientific work and what aspects were not. The text and the teaching act were "epistimologically flat," which is the term suggested by Kilbourn to characterize situations where epistimological issues such as the nature of science are central to fulfilling intended outcomes, but the effort of curriculum writers or classroom teachers falls short of dealing adequately with those issues. A conviction that Kilbourn shared with many others (Renner, 1982; Schneider et al., 1980; and this researcher as well) is that it is the responsibility of the curriculum developer and, more importantly, the classroom teacher to explicitly provide learners with an awareness of any epistimological issue in a clear and active manner.

John Olson (1981) reported a case study in which he tried to understand how teachers used the material of a science program designed in Canada to apply certain innovative doctrines. Eight teachers participated in the study, and a variety of data collecting procedures were used; several qualitative and quantitative analyses were also employed. Olson found that teachers see the innovations as increasing the diffusion of their work. Curriculum materials have been translated by teachers into more specific and familiar terms which derive their meaning from the existing vocabulary of the teacher. For example, discussion became lectures and recitations, intellectual skills development was translated as content memorization and examination rehearsal, and the integrated design was translated as a patchwork of specialized content. Important elements of the innovation materials were either ignored or redefined in more traditional terms. To deal with such practice and to have a better chance for innovation to be employed, Olson suggested that innovation material should be written in the working language of classroom practice where teachers do not need to make translations which change the images that the innovators tried to present. Curriculum writers should understand the ways teachers use instructional materials practically and take these ways into their consideration. Such kind of understanding should also be based on the social, institutional, and individual realities in which teachers usually work.

A naturalistic study was conducted by Hills (1981) to focus on the efforts of a seventh grade student to solve problems using the algebraic approach. Strategies of clinical interview were used in order to reveal what was involved in the students' attempts to make sense of the problems of the textbook. The study concluded that they were systematic and fundamental differences between procedures prescribed by the textbook and those actually used by the student in working out certain problems. These differences are not easy to detect from their written work on paper; and in order to learn more about why students experience difficulties in solving problems, researchers are advised by Hills to pay attention to what students say and do as they work out these problems.

During the last decade, there has been a growing number of studies revealing evidences that students of various grade levels have certain scientific conceptions which are different from accepted scientific theories and which are resistent to change in spite of formal instruction. The relevance of this kind of research to this study of science teaching and learning in Jordan is the students' understanding of knowledge of the topic being the central focus. In addition to this common focus, most of this research, sometimes called research on misconceptions in science, have dealt with small numbers of students, and direct observation and clinical interview were employed. Researchers in this field share an interest in content-related conceptual development rather than a general intellectual development. A brief review of several chosen studies will follow.

A group of researchers in science education met in a conference in April, 1982, at Leicester University in Great Britain. The conference was devoted to the investigation of students' existing ideas about science and how they affect students' learning. Fifteen papers were discussed at that conference. Sutton and West (1982) reported a summary of these papers and analyzed the papers and the participants' discussions of them. This area of research was viewed as a new field in science education which is fast-growing and gaining acceptance. Origins of students' conceptions about science were suggested to be coming from the immediate physical experience, from language usage, from beliefs and opinions encountered by peers, and from formal and informal instruction. Research on students' conceptions of science was considered essential because it focused on the nature of the students' learning which is the basic goal of education. The researchers in this conference seemed to rely on two major assumptions: that students need to construct their own learning and that students' present knowledge influences their responses to new knowledge. The presentation of papers and the discussion of researchers' perspectives revealed that there are several interesting ideas shared by those researchers. The following are among those ideas:

--concepts are not fixed entites that students can have or not; these concepts change as students develop and learn

--different and sometimes conflicting ideas can exist simultaneously in students' minds

--useful information about students' learning can be collected, in part at least, using interviews

--learning is more than repeating in a verbatim form what has been presented in the classroom; it involves students in constructing their own meaning from the formal or informal instructions

--social interactions influence the private understandings of the student

Dealing with students' misconceptions can take either a revolutionary or evolutionary approach. Researchers using the revolutionary approach were concerned with identifying alternative frameworks, their nature and incidences; they viewed these frameworks as barriers to science learning. Researchers using the evolutionary approach, on the other hand, were concerned with relationships among concepts and propostions and made emphasis on using the feedback from using the relationships, integrations, and differentiations in teaching.

Nussbaum and Novick (1982) presented in their study an instructional strategy to deal with students' misconceptions they called alternative frameworks. The suggested strategy is based on the thesis that science concept learning involves cognitive accommodation of an initially held alternative framework. The strategy consists of three phases: exposing alternative frameworks, creating conceptual conflict, and encouraging cognitive accommodation. The first phase is facilitated through an exposing event while the second and third focus on a discrepant event. The authors have used previous research findings about student alternative frameworks of the structure of gas, to create exposing and discrepant events for an introduction to the particle model of gases. They presented a case study of two lessons in a sequence on the particle model and an analysis of the phases of the instructional strategy which they employed to get students to achieve the cognitive accommodation. The suggested strategy was found to contribute to students' conceptual change and accommodation in various ways: being aware of their alternative framework, feeling the need for a theoretical model, engaging in meaningful discussion, and experiencing the conceptual conflict which enhances the accommodation. Teachers who have good skills in listening and creating exposure events are needed to expose and analyze students' alternative frameworks and help them pass conceptual conflicts into a more adequate cognitive accommodation.

Fifty-five papers were presented at the international seminar on students' misconceptions in science and mathematics in Ithaca, New York, in June 1983. The papers are included in the proceedings of that seminar (Helm & Novak, 1983); they can be considered a representative sample of the reports of studies conducted in that field in various countries of the world. The 118 researchers participating in this seminar were in agreement that many of the science and mathematics curriculum projects of the 1950s and 1960s failed to achieve their goals because they failed to recognize the influence of students' prior knowledge and their resistance to change during instruction. The students' prior conceptual frameworks, often called student misconceptions, have a profound influence in shaping the meaning of what students learn in the classroom. During the discussion sessions of the seminar, the participant identified several important issues which can be summarized in the following point:

--teachers are usually not aware of students' misconceptions, and they discuss topics of instruction as though students were tape recorders.

--textbooks sometimes are at fault; they contain misleading and incorrect information

--teachers, too, hold misconceptions

--students are skillful in hiding their misconceptions

--problems of students' misconceptions is a complex and multifaceted one that has no easy "quick fix" (Novak, 1983)

The papers presented in this seminar covered different issues related to the problem. Thirteen papers dealt with theoretical, historical, and philosophical issues; twelve papers deal with methodological issues; nine with instructional issues; and the rest of the papers dealt with certain concepts of elementary and secondary school science. Only one paper was related to chemistry, 11 to physics, six to biology, and five to mathematics.

Summary

In this chapter, an attempt was made to review the literature related to the topic of this study, teaching and learning chemistry and the methodologies related to it. Present status and future trends in chemistry teaching and learning in various places in the world were summarized first. It was found that innovations in curriculum development in chemistry have been taking place since the late 1950s. Results of those innovations did not manifest unique desirable learning outcomes; enrollment in chemistry courses was decreasing, especially in countries where students have choices; attitudes toward chemistry were not improving significantly; and the laboratory role in chemistry education was losing ground. Many chemistry concepts have an abstract nature which was not easy for many students to understand, especially with teachers who lack the experience and good training and with too much material to cover in a short time. Recent trends in chemistry education emphasized social and environmental issues, stressing the quality over the quantity, and the need of teachers to reflect and understand more about that work. The nature of chemistry education in Jordan was presented in Chapter I and more details and the cornerstone of chemistry which is the particle model or theory of matter is presented in Chapter IV.

Ethnography as a research approach was presented as a methodology for understanding the teaching learning process. What characterizes ethnographic approach from the dominant experimental, correlational, and statistical approaches, was mentioned briefly. The assumptions that researchers in this tradition have employed, the questions they asked, and the nature of their techniques and findings were also presented. It was emphasized that ethnography is not a replacement for other approaches; each approach has its merits and should be used separately or together, depending on the type of research, the kinds of questions, and the nature of decisions to be made. Examples of research in science teaching and learning using ethnographic approach were reviewed. More details about the ethnographic techniques which were used in this study are included in Chapter III.

Finally, research on teaching and learning science which makes the content-related conceptual development its focus was reviewed and found to be a new field of research, but one getting increasing interest and acceptance.

The literature reviewed in this chapter provided a useful background for this study. The present status and future trends of chemistry education allowed for better understanding of the topic of this study by relating it to what happens in other settings in the United States and to obtain a broader perspective. Reviewing ethnographic approach as a methodology for understanding the classroom system was helpful in showing how various tools and techniques of ethnography have been used by other researchers and in dealing with the value of these tools and techniques for the purpose of this study. Research on teaching and learning science which relates the subject matter in the curriculum materials, the classroom instruction, and the students' learning outcomes in a combined case study was found an important and still growing area which needs further research efforts. This study was an attempt to provide some contribution in this area and to improve our understanding of teaching and learning science in Jordan.

CHAPTER III

DESCRIPTION OF THE STUDY

Research Design

This study uses a case study approach to describe and examine the interrelationships among three components of teaching learning process: the program materials, the actual instruction, and the students' learning. The case study described one teacher, Miss Hanan Talib, and one of her tenth grade classrooms in the natural science program at Northeastern Girls Secondary School in a major town in Jordan during a period of seven consecutive weeks. The subject matter addressed in this study, the properties of matter and the particle model, was the focal point in the three components. The subject matter was analyzed to identify the goals and objective of the scientific knowledge prescribed in the textbook, suggested in the teachers' guide, covered in the instruction, or learned by the students.

This case study has used qualitative and quantitative types of evidence and employed ethnographic methods in collecting data. Figure 1 illustrates the research model developed in this study.

The figure illustrates that the research work has three components: the research strategy, the type of evidence, and the data collection. Each needs to be decided upon. These three components have interrelationships among each other. Each also contributes to the choice of design to be used in the research.

The special combination of the three foci in one study and the types of questions addressed in it, as presented in Chapter I, need a special research design which employs a variety of methods and perspectives in an eclectic

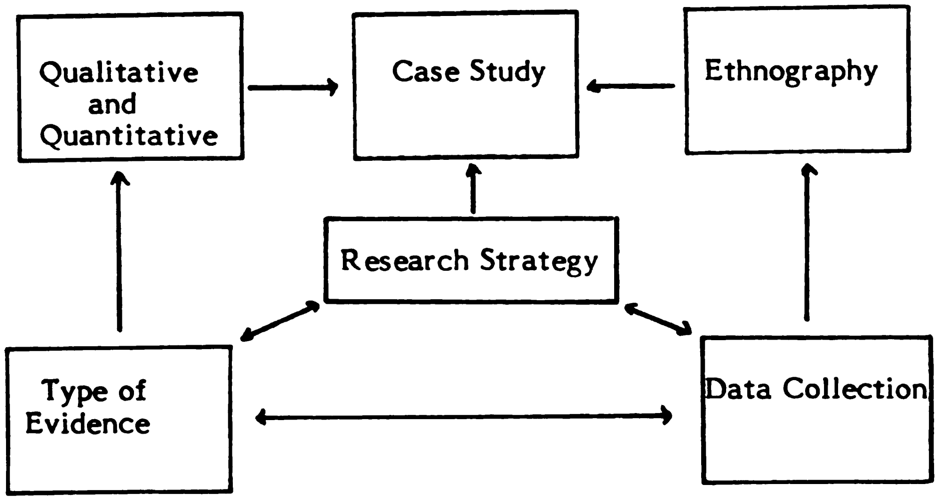

Figure 1: The research design.

approach. Ethnographic research as described in Chapter II uses varius procedures and techniques to answer questions about events of interest and to seek clarification and evidences from various sources. The strength of ethnographic research in addition to the combination of qualitative and quantitative sources of support made the research design of the study a unique one.

Search for the Setting

Earlier in Chapter I, a rationale was given for choosing the examination of the natural sciences course (NSC) for the tenth grade. Science supervisors in the three largest school districts in Jordan where approximately 75% of the students of the East Bank* are located were asked to identify whom they considered to be the best six teachers among those who teach NSC for the tenth grade and to provide some background information about each of them. This background information included experience in teaching, academic qualifications, and reasons for choosing the particular teacher among the best. A questionnaire was

*The West Bank of Jordan has been under Israeli occupation since 1967.

sent to each chosen teacher (18 teachers: nine males and nine females) to collect basic knowledge about their teaching practices, such as using the textbook, teachers' guide, and other references; using the lab and doing demonstrations; problems and difficulties faced in teaching; and his/her willingness to participate in the main study. Appendices I and J show the questionnaire for supervisors and the questionnaire for teachers. These data helped in choosing several candidate teachers for the study.

Although special cases have the value of examining what was special in each case, in order to follow a good example or to avoid a bad one, they lack the possibility of making generalizations from them in the traditional definition of generalizability (Bagdon & Biklen, 1982). In this study, however, the choice of having a good teacher was made to avoid cases which might not help to continue the study. The practical circumstances of doing this research include providing the basis for choosing a good teacher who is likely to be a good choice for the study is a teacher who can understand and appreciate circumstances such as investigating the target setting in Jordan while the researcher is in the USA, the timeframe available for being on site, the unusual burden on the teacher of having an observer with videotape equipment in the classroom for approximately 10 weeks, and the need for having the teacher spend extra time with the researcher for interviews without financial compensation. Various problems have been recognized in the classrooms of beginning teachers and those who are weak in subject matter, but what happens with a good teacher is not very well understood.

An attempt was made, however, to avoid certain special cases which might not be representative of the majority of classrooms. Teachers who were teaching for the first year or who were teaching NSC for the first time were excluded. By the time the researcher arrived in Jordan to meet with the candidate teachers, he had the opportunity to find almost all Jordanian chemistry teachers in one place, grading the general examination for the first semester. After discussing the purpose and procedures of the study with these candidates, the researcher found it would not be easy for most of them to participate in the study. However, with some hesitation Miss Talib showed some interest to "give a try, to make use of the experiences of others, and to develop (her) abilities and skills in teaching."

Miss Talib is a 26 year old who received her Bachelor's degree in chemistry at the University of Jordan and her diploma in education at Yarmouk University. This is her fourth year of teaching, but the second year she has taught NSC to the tenth grade. Northeastern Girls Secondary School (NGSS) where Miss Talib teaches is located on the east side of a major town in the northern part of the East Bank of Jordan. Like many other inner city or large town schools in Jordan, NGSS is overcrowded by a large number of students (58-65 students per classroom in tenth grade, 40-45 in eleventh and twelfth grade classrooms). The school was built in 1953 and started as an elementary school. It was changed to an elementary and preparatory school sometime later. Since 1977, it has been the only secondary school in the north and east parts of the town. Secondary school students from various villages in the area are also accommodated in this school. It has 21 classrooms this semester: five tenth grades, six eleventh grades, and 10 twelfth grades. The total number of students exceeds 1000, most of them coming from low and middle classes in terms of economic level. Almost 50% of them come from families living in the nearby villages. The Jordanian government pays the salaries of all employees and teachers in the school system and provides most of the equipment and furniture there. Local expenditures related to daily requirements of practical activities in art, home economics, physical educaiton, science labs, etc., are paid from the school budget which is approximately JD4000 this year (approximately $12,000). The source of this budget is student fees (usually called donations). About 30% of the students do not pay these fees because they are considered to come from poor families.

Miss Talib has taught NSC and chemistry for eleventh and twelfth graders, so she is aware of the structure of the chemistry program at the secondary school. This year she teaches NSC for two sections of tenth grade and chemistry for five sections of twelfth graders, a total of 23 periods a week. She is responsible for the school committee of cosmotology and is a school monitor one day a week. She has been excluded from one major responsibility that all teachers share--being a classroom referee for a particular classroom. Each classroom has a referee who keeps records of student developments in all aspects, academic achievements, and social and psychological problems and reports to the school office any problems related to students in that classroom, as well as trying to help students with their special needs. Miss Talib is excluded from this responsibility because she has a teaching load which exceeds the prescribed one in addition to her other administrative and instructional responsibilities.

Miss Talib was chosen first by the science supervisor as one of the best teachers; this is also the way she thinks of herself and the way the principal described her in the first interview. In an interview with the researcher, the science supervisor for the Northern School District stated:

> I thought that (Miss Talib) will be among the best for the purposes of your study. She is a confident person with a strong personality. But as far as teaching is concerned, she represents the mainstream of teachers in our schools (Interview, January 28, 1982).

In her third interview with the researcher, the school principal stated:

> Miss Talib is a sincere teacher. I do not have special problems with her. No problems have been reported from students about her teaching. She is not that type of teacher who asks repeatedly for leaves or excuses. I know her very well because I taught her when she was a student in the secondary school . . .
>
> In regard to the lab work, like most teachers she has a negative attitude. Most teachers are not ready to spend time to prepare for experiments outside the schedule of the school day. Planning is a problem for most teachers, also. Miss Talib shares with most teachers this negative attitude toward planning, although she prepares her lessons and tries to meet the specified requirements; however, I heard her yesterday telling you that there is no difference between writing the lesson plan before the lesson or after the lesson. This is really a dangerous idea (Interview, March 3, 1982).

The above extracts from the science supervisor and school principal's interviews have many implications, but it is sufficient to say at this point that they both describe Miss Talib as a teacher who is among the best in terms of personality, management, and social relationship. But when teaching behaviors become a criterion, they both describe her as a typical teacher. Typicality of teaching behavior of Miss Talib was noticed by five professors of education who have 15-25 years of experience in science education and teacher education in Jordan when they viewed one tape of Miss Talib's classroom.

Getting into the Classroom

After the approval of Miss Talib to participate in the study, at least in principle, several legal and administrative steps were taken to secure formal approval of the director of the school district and the school principal. Also obtained was the permission of the director of a nearby community college to use the college's video equipment and to secure a leave for an audiovisual instructor to help as a cameraman.

Several points were discussed and clarified with Miss Talib before classroom observations took place. Among these, the researcher pointed out that there was no need to change the natural setting of the classroom for the purpose of the study because the intention was to study classroom activities as they actually occurred. The teacher pointed out that she hoped there would be no obtrusiveness or disruption to the school's schedule or instructional events in the classroom because she had a tight schedule and had no time to "sacrifice for the purpose of doing experiments . . . " Assurances were also given for the confidentiality of all names associated with the school and classroom setting, but permission was given for viewing or listening to the tapes by persons related to the design of the study. The first lesson was observed without using any equipment. The teacher introduced the researcher to the class as the author of the unit they would start studying this semester, saying that he was doing a research project to examine how this unit is being used, taught, and learned in the classroom setting and that for this purpose he was going to use audio and video recording of the classroom activities as they naturally occurred. A place was reserved for the researcher in the back of the room, the first lesson began, and the researcher started writing his fieldnotes.

The classroom for section one of the tenth grade was located in the west corner of the third floor. The arrangements and area of the classroom were similar to those of all other classrooms in the school. Figure 2 illustrates the design and physical arrangement of the classroom.

The area of the classroom was 7x5 meters or $35m^2$. It had 31 standard student desks for two students each and one table and chair for the teacher. It had one door in the corner, three large windows on the west wall, coat hangers in the back, a green chalkboard with a bulletin board on each side, a book shelf cabinet in the corner facing the door, a small first aid cabinet on the east wall, and a waste basket near the door. With this arrangement, the classroom could accommodate 62 students; there were 59 present during the first lesson of observation.

Participant Observation

The researcher was a participant observer in the classroom during the 26 lessons in which the teacher covered the subject matter of the first three chapters of NSC during the winter of 1982. Being a participant observer, the researcher shared the teacher and students' lives and experiences. He took notes of instructional activities, and he also carefully observed various features of the classroom world: role taking, verbal and nonverbal interactions, work on the chalkboard, seat work, feelings exchanges, intellectual exercises, and conceptual development. Before each lesson began and after it ended, he had chances to talk to students about various topics, to examine the content of their notebooks, and to ask about the meanings of behaviors. The classroom observations and casual conversations with students before and after lessons served to identify points of interest for later interviews. There were occasions where the researcher as participant observer was asked to clarify points of disagreement between the teacher and students and occasions where he volunteered to clarify some point or ask some questions. Toward the end of the period of observation, he was asked to spend the whole lesson with the students in a question/answer session. In the lab session, he helped in setting up the experiment and fixed equipment when it failed to work adequately.

But the central assumption of participant observation is the fact that the researcher has shared, as intimately as possible, in the life and activities of the classroom, trying to adopt the perspectives of the other participants (Denzin, 1978).

Part of the researcher's fieldnotes were written in the classroom, but many of them were written after leaving the classroom. Fieldnotes included descriptions of the happenings as the researcher saw, heard, and experienced them; but they also included his own reflection, classification, and

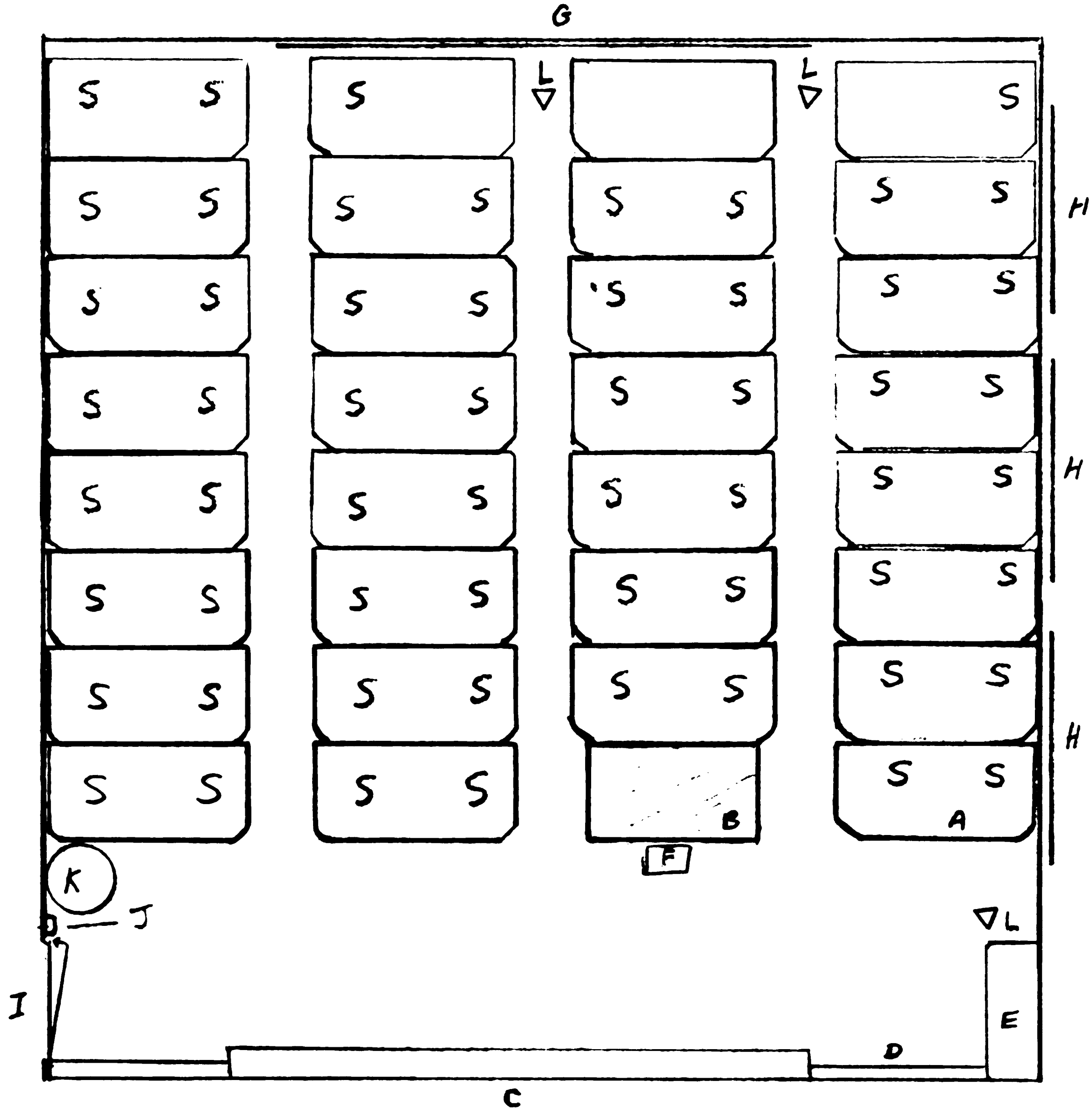

Figure 2. The classroom.

Key:

A	Student desks
B	Teacher's desk
C	Chalkboard
D	Bulletin board
E	Book shelves
F	Teacher's chair
G	Coat hangers
H	Windows
I	Door
J	First aid
K	Waste basket
L	Camera positions

understandings of what happened and some points to follow, clarify, or test in later observations.

Interviews

Understanding cannot be complete by just observing and recording the ongoing sequences of behavior. The observation usually raises questions which need direct and purposeful talk to resolve them. Trying to consider the perspective of an individual needs testing to see whether this individual really holds this perspective. Interviews elicit various kinds of responses and knowledge which fill the gaps that the researcher finds after reviewing and reflecting the fieldnotes of the observation. An interview was defined by Maccoby and Maccoby (1954) as "a face to face verbal interchange in which one person, the interviewer, attempts to elicit information or expression of opinions or beliefs from another person or persons (p. 499).

Although the kind of knowledge elicited from various interviews in this study were very useful, the task of doing them was very difficult. Finding time to schedule the interviews was one barrier; a place in the school to hold the interviews was a problem; the embarrassment of having a man (the researcher) sitting with a woman (the teacher, the principal, or a student), talking privately, trying not to involve others in listening to the conversation, was also considered a problem in the local culture; and, finally, the natural feeling that the interviewer was organizing the interview, directing the conversation for certain purposes of his own work, was also an obstacle, especially when the interview was tape recorded.

Despite all these problems which should be considered in the context of analyzing the content, the researcher was able to hold the following interviews:

1. three tape recorded interviews with the teacher and several other casual interviews and conversations which were not recorded;

2. two tape recorded interviews with the school principal, one unrecorded interview, and several informal conversations;

3. tape recorded interviews with six students, unrecorded interviews with five students, and casual/informal conversations with many other students (reported in fieldnotes);

4. five tape recorded interviews with a university professors after viewing one taped lesson of Miss Talib's classroom; and

5. two interviews, one tape recorded and one not, with two science supervisors.

These various interviews provided the researcher with a wealth of information and perspectives for understanding the teaching and learning of science in Jordan, with reference to this case study in particular. In planning the interviews, the researcher used Denzin's (1978) chapter on sociological interview as a guide.

Machine Recording

Writing fieldnotes directly during the classroom observations or interviews is very important, but there are so many things to observe which cannot be reported instantly in the fieldnotes. Audio and video recorders have helped greatly in reproducing events so they can be seen or heard again and again to capture many of the details which did not get the attention of the observer the first time. With a special focus on teaching and learning the subject matter addressed in the textbook, it was necessary to document all verbal communications in the classroom for a later analysis of the content of the communications. This documentation was done through audio or video taping. The observer did not have to spend much time writing what the teacher said or what a student responded; therefore, more time was available to attend to other activities such as how students used their notebooks and the way the teacher presented her questions and the students responded. On the second visit to the classroom, an audio cassette tape recorder was used with a small, wireless microphone carried by the teacher in her hand (she felt uncomfortable hanging the microphone around her neck). The receiver was built into the cassette recorder as an FM radio. For the next two lessons, the microphone was placed in the pocket of the teacher's jacket. Another tape recorder with two sensitive, built-in microphones was used for the rest of the lessons in order to reduce the inconvenience of using the wireless microphone. The recorder in the last case was so sensitive that it captured most of the classroom's verbal communication while it was located in the back of the classroom near the observer.

As the teacher started teaching chapter two, a video camera was introduced into the classroom. Eleven of the 26 lessons for Chapters 2 and 3 were videotaped. In addition to documenting the verbal communication, which the audio tape recorder did, the video recorder documented the sound and the picture. Mr. Shadi, an instructor of audiovisual courses at the local community college, helped as cameraman for most of the videotaped lessons. The researcher himself was the cameraman for the rest of the lessons.

The purpose of producing a documentary videotape of the classroom is to preserve a record of actual happenings, the stream of events of classroom life in space and across time. Using a video camera involves a choice of recording a sample of the classroom events at a single moment because many different things happen at each moment. The camera was mounted on a tripod in a given place during lessons, but the cameraman moved the camera, changing the angle and breadth of the shot to take into the scene individuals and places of major activity in the lesson, such as writing on the board, showing a model, a student answering a question, etc. One camera was placed in three locations on different days in order to show the lessons from different angles. The physical arrangement of the classroom did not permit setting the camera in a position where it could include within its frame all the classroom participants at the same time.

Actual sequence and real time duration of events were preserved in both audio- and videotapes in order to be used as data sources during the analysis process. Audiotape copies from the videotapes were made in order to make use of the audiotapes when the videotapes were not needed and verbal communication was the focus of interest in the analysis.

Official Documents

The written words of the participants in the research setting, made or produced as part of their routines, or as reports and records related to the nature of their work, constituted another source of data. Large filing cabinets in various offices and departments of the Ministry of Education needing large storage areas have huge amounts of data about schools and other organizations which, if researched adequately, can provide a strong knowledge base for improvement. Since the researcher worked for some time as a chemistry member of the curriculum department of the Ministry of Education, he was aware of this source of knowledge about teaching and learning chemistry, particularly of the NSC. He secured permission to examine the files of NSC at the curriculum department which included documents such as teachers' evaluation forms on which science supervisors report classroom practices of teachers based on visits to those classrooms, teachers' yearly reports for evaluating textbooks, and questionnaires completed by science supervisors and teachers at the request of the curriculum department which speak to problems or difficulties faced at the local level.

The file for the Northeastern Girls Secondary School was examined at the school district's education office. The researcher also reviewed many documents at the school level, including Miss Talib's lab record which she filled in and signed each time she used the lab for doing practical activity or checking out some equipment to use in the classroom. Miss Talib's long and short range written plans were examined, and planning books of other teachers were also made available for the researcher. Student notebooks and lab books for Miss Talib's classroom were also investigated. Photocopies of some of these documents were taken and kept by the researcher for further examination.

Testing Students' Learning

All the above mentioned methods of data collection are considered the basic means of collecting qualitative data, but they can also generate quantitative data. In this classroom, testing was considered basically a means of generating quantitative data, but it was also also very helpful in generating qualitative data. Tests made by the researcher and reviewed by Miss Talib were used before instruction to provide an idea about students' prior knowledge and to provide a means to test their prior knowledge against the knowledge they have after instruction in terms of quality and quantity. Multiple choice items were used in most tests to examine some expected alternative frameworks that students hold. The items of each test cover almost all the concepts and ideas in the chapter. Free response questions were also used to give students the chance to express their knowledge without any prior clues or indicators and to test the meaningfulness and clarity of the statements they wrote in response to those free response questions.

Overview of the Research Procedures

This study used a case study strategy in which ethnographic data collecting methods were used and qualitative and quantitative types of evidence were employed. The entry step in which the researcher made personal contact with the teacher who was the principal informant in the field was an important and critical one. Official and administrative contacts were used, and personal and social contacts were critical in facilitating the entry step. Without engaging the researcher's wife and parents and the teacher's parents and grandparents, the researcher would not have succeeded. Sometimes entry becomes an overwhelming obstacle because the teacher in such studies might be reluctant to allow the observer to be in the classroom for an extended period of time. Eldridge (1981) has reported that he failed to start her observations in classrooms three times. Each time, the teacher agreed to participate in the study, then s/he called the next day to tell the researcher that, after thinking it over, s/he would not be able to spend the required time and effort in the study.

In this study, the data collection period lasted for 10 weeks during the winter of 1982. Participant observation, interviews, audio- and videotape recordings, tests, and examination of records were used as data collecting methods. Data collecting started before entering the research site when the researcher examined related curriculum materials and official files and documents.

Data analysis is the stage in which the researcher tries to organize the data s/he has collected, break it down into units, search for regularities and patterns, and find out some that s/he can tell others about his/her research. In the case of this study, part of this analysis was done during the stage of data collection where the researcher had some ideas or hunches about what was going on and he looked for confirming or disconfirming evidence by examining the data he already had or looking for more data to collect. Data analysis in this study included an intensive analysis of the classroom teaching/learning process, the subject matter of the unit as addressed in the textbook and teachers' guide or the antecedents, and the students' learning outcomes or results.

Analysis of the Program Materials

The chemistry curriculum pamphlet of the secondary school science was reviewed to identify the goals and objectives of teaching science in Jordan and the major conceptual and process themes the Ministry of Education asked the authors of the textbook to consider and apply in writing the textbook and teachers' guide. Propositional knowledge addressed in the NSC textbook and teachers' guide was analyzed using the procedures of analysis described by Landes, Smith, and Anderson (1980). This literal analysis was considered as part of the author's intentions for teaching the program and provided a basis for comparing with the knowledge addressed in the actual classroom instruction.

Analysis of the Actual Instruction

Actual instruction, classroom teaching and learning interactions, and the ways in which the program material was used in the classroom were documented and recorded in the form of fieldnotes, and audio- and videotape recordings. The meanings and importance of certain events in the classroom were also discussed with participants reflecting different perspectives, including those of teachers, students, school principal, and several teacher educators. These discussions were also documented in fieldnotes or audiotape recordings. Audio-and videotapes of classroom lessons and interviews were reviewed several times, and transcripts were made for more careful study whenever the situation so warranted. Propositional knowledge addressed in the classroom lessons was also analyzed using codes to refer to the proposition, the chapter in the textbook, the lesson, and the person who addressed the proposition (the teacher or student).

Besides propositional knowledge, several other aspects of classroom instruction were analyzed. Verbal interaction was analyzed using Flanders Interaction Analysis Categories (FIAC). Several quantitative and qualitative aspects of this verbal interaction were examined, such as the amount of time spent in teacher talk or student talk, the number and type of teacher's questions, the types of students' responses, and control of knowledge and the social order. Students' categories in the classroom were identified by examining the nature of their behavior and the type of the teacher's treatment.

Analysis of Students' Learning Outcomes

The research used three different types of data to examine the learning outcomes of students: students' interactions in the classroom, their responses and discussions in interviews, and their responses on the pre- and posttests. Students responses on five multiple choice tests were analyzed by computer tofind out the frequencies of student responses to various alternative frameworks. Responses on items before and after instruction served as a base to analyze the nature of students' prior knowledge and its effect on students' learning. Special attention was given to examining various types of instructional objectives, including cognitive knowledge, process skills, and attitudes.

The items of all tests were analyzed to identify the alternative frameworks addressed in each item as different scientific propositions and the number of students who held each framework before and after the instruction was found.

Writing the Research Report

This dissertation is the summary of the research work conducted in this study. It has reported what has actually been done. In the process of conducting the study, several things have changed from the way they were originally planned. New ideas were developed, new questions were raised, and new procedures were employed. This kind of change is expected and is usually characteristic of this type of research. The broad questions which initiated the study continued to guide the research process to the end; but between entering and leaving the research setting, many other questions were raised. These questions are more in number, but narrower in scope. The initial questions were broad; for example, "How does the teacher use the curriculum material in the classroom?" The new questions varied in scope, but at the end they focus on specifics and particulars; for example, "Why did the teacher mention that electrons flow from the positive terminal of a battery to the negative one, contrary to what the textbook employs?" "What was the effect of reprimanding Hawazin on her attentiveness when she failed to respond correctly to the question about the definition of the second law of chemical composition?" "What did Manal write in her notebook about the experiment of discharge tube?" etc.

Toward the end, responses to these many and specific questions were synthesized together to make more general statements about the whole situation in an attempt to respond to the initial questions which are small in number and broad in scope. Figure 3-3 illustrates the difference in the number and scope of questions during the research process.

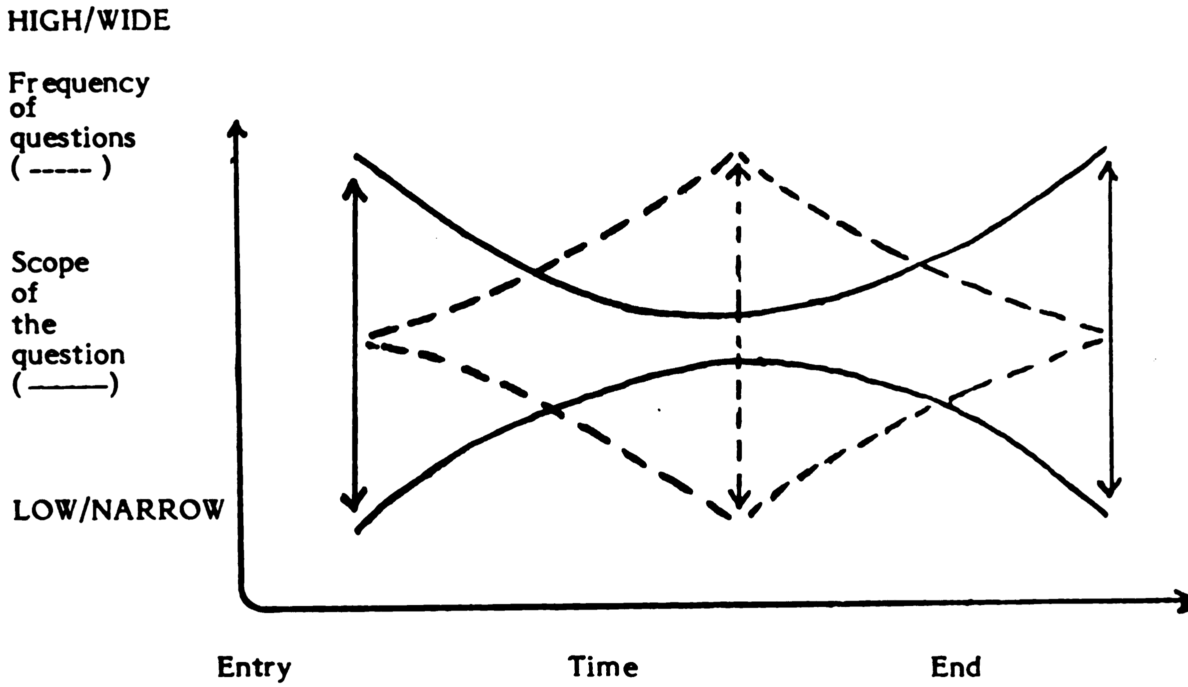

Figure 3-3. Scope and frequency of quesitons in the research process.

CHAPTER IV

ANALYSIS OF DATA

Overview of the Chapter

This case study touches some aspects of Schwab's four commonplaces of education: the teacher, the learner, subject matter, and the milieu. The focal point, however, is the knowledge of subject matter as presented in curriculum materials in classroom teaching and in student learning. Figure 4-1 shows the relationship of the different components of the teaching-learning process which were addressed in this study.

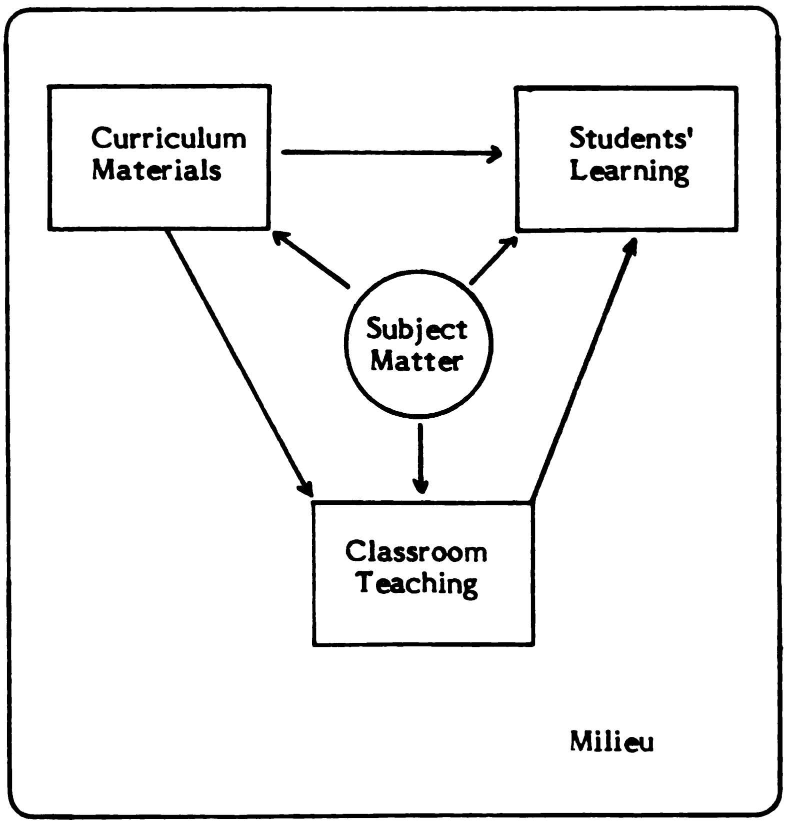

Figure 4-1. The interrelationships of the components of the study.

The purpose of this chapter was to describe the curriculum materials, teaching activities, and students' learning within the social context of the classroom in particular and the school in general. The purpose of this description was an attempt to understand the teaching-learning process of a tenth grade science classroom at Northeastern Girls Secondary School in a major town in the north part of Jordan.

The curriculum materials were described first, indicating the objectives and content of the curriculum, the basic structure and organization of the subject matter in the curriculum pamphlet, the students' textbook, and the teachers' guide. Teaching activities were described next. Three teaching activities were identified: planning, classroom instruction, and evaluation. Some quantitative and qualitative aspects of classroom interaction were also described. Finally, students' learning outcomes were described through analysis of the students' participation in the classroom, their responses to the researchers' questions during interviews, and their performance on several written examinations. A summary was also provided at the end of the chapter.

The Development of the Natural Science Course

In 1963 the Ministry of Education of Jordan began a major effort to reform school education in all subjects at all levels. An educational act, No. 16, 1964, was suggested and passed by the parliament and was considered to be a revolution in education. In this educational act, the philosophy of education in the Jordanian society was redefined and based on the urgent and expected societal needs of the country. The act also included a definition of the general goals of education and general educational goals for each subject matter at each school level: elementary (grades 1-6), preparatory (grades 7-9), and secondary (grades 10-12).

By 1969 the new school curriculum and textbooks in all school subjects were prepared and implemented at the elementary and preparatory levels. Other committees were appointed to redesign the school curriculum at the secondary level. Three different committees were assigned the responsibility of designing the curriculum in physics, chemistry, and biology. Members of each committee represented the University of Jordan, teachers' training colleges, science supervisors, secondary school teachers, and the Department of Curriculum and Textbooks at the Ministry of Education.

After drafting the major themes and concepts in the three subjects and distributing them to three secondary grades (10, 11, and 12), a decision was made to reconsider the kind of science necessary for tenth grade students before they are classified at the end of the year into science and literature branches for the eleventh and twelfth grades (see Table 1-1). The natural science course (NSC) was developed as a reuslt of this consideration.

The subject matter of this course was organized in four units:

1. measurement, experimentation, prediction, and explanation;
2. equilibrium;
3. properties of matter and the particle model; and
4. energy.

The content of each unit is shown in Appendix A.

Content and Organization of the Curriculum Materials

Curriculum materials related to the natural science course for tenth graders are a curriculum pamphlet, students' textbook, and teachers' guide. The researcher was one of the authors of the these three components of the NSC materials. Since the intentions of the authors of these materials might be difficult for teachers to infer in a way which is similar to what they can describe, this researcher will try in this analysis to detach himself from this background and depend on the written words of the materials for describing the intentions and perspectives of the curriculum materials. Whenever the researcher's perspective is being employed, it will be indicated clearly.

Curriculum Pamphlet

The curriculum pamphlet is organized around four headings: goals, content, instructional activities and techniques, and evaluation. Goals are written in brief and general terms. they include three basic statements referring ot the three domains of instructional goals: cognitive knowledge, habits and attitudes, and psychomotor skills. Content is presented in a considerably detailed manner in which topics, subtopics, and examples are related directly to suggested activities and methods of presentation in the following way:

Content: topics subtopics, and examples	Methods and techniques of presentation	Practical activities experiments, films, etc.

The evaluation portion of the curriculum emphasized the concept of continuous assessment of students' acheivement, curriculum materials, and instructional activities.

The curriculum pamphlet and various official letters related to the curriculum which are usually sent by the Ministry of Education to inform teachers of any changes or modifications in the curriculum should be officially available to teachers.

Textbooks

The textbook came in two volumes. The first volume consisted of units one and two and was taught in the first semester of the year; the second volume, consisting of units three and four, was taught in the second semester. The content of unit three which was the focus of analysis in this study is shown in Appendix B.

The textbook was written in a language in which the writers address the individual reader. Definitions, main concepts, and conclusions were printed in blue. Equivalent English terms are added directly after main concepts. Some conclusions and definitions are repeated or paraphrased and printed in blue in page margins. All figures and diagrams in the textbook were drawn by hand; none of them was a photograph of real equipment. One of the features of the textbook is the use of questions, especially before or after describing an experiment. Sometimes the answers were provided; sometimes not. Each chapter ended with chapter questions and problems. Chapter questions had various forms: multiple choice, short answer, essay, matching, and numerical problems.

The general and specific goals of the NSC textbook, volume two, were mentioned in the introduction to the book. General goals are the same goals of science education as presented in the curriculum pamphlet:

1. to acquire basic knowledge required to understand and explain natural phenomena and realize the regularity, conformity, and aesthetic aspects of the world;

2. to udnerstand the nature of science as a human intellectual activity, to recognize the importance of science and its contributions to human life and to appreciate the work of scientists; and

3. to develop scientific attitudes, intellectual, and psychomotor skills; i.e., the accuracy of observation and work, the ability to

analyze the results, and the habits of patience and perseverence, suspending judgments, scientific reading, and appreciation of research.

Specific goals of this textbook are:

1. to explain the natural phenomena which are related to the properties of matter and its structure, to recognize th laws that control the behavior of matter and its changes and illustrate the efforts of scientists which they have done to reach the contemporary scientific achievements; and

2. to recognize the forms and changes of energy, to understand the principles on which various apparatuses and devices work and the practical application of energy, to understand the importance of energy in the civilization of contemporary society, how to develop and use energy sources to meet the increasing demands of human societies (Abanda, 1976, p. c).

The first chapter in the textbook started with a short introduction to point out that the central issue in the whole unit, the structure of matter, was an old issue. It required a great genius from skillful scientists to conduct experiments and construct theories. It is possible, however, "for anyone to conduct these experiments and arrive at the conviction of the existence of molecules and atoms" (p. 1). Gas laws were referred to very briefly, but several simple experiments regarding the properties of gas were required to be conducted in order to interpret the differences among various gases in terms of the differences among the molecules of those gases. Laws of chemical composition were presented through two numerical examples and a definition of each law. The rationale of introducing those two topics in the textbook was to see that the behavior of gases and their chemical composition as described by empirical laws are explained by referring to the existence of the molecule and the atom. At this point, the concepts of element and compound were introduced and defined using the models of the molecule and atom, and the basis for chemical symbols and formulas were established.

The kinetic molecular theory assumed that molecules have no volume and do not have attraction forces among them. But there is no such gas with these characteristics; it is an ideal gas. Practically, we deal with real gas which deviates from the behavior of ideal gas. The concept of mole was also introduced through Avogadro's hypothesis and used in numerical problems. Chapter I ended with a table of all known elements, indicating their symbols, atomic weights, and atomic numbers.

The second chapter began with explaining the properties of pure substance and how the change in phases of a substance can help in identifying the kind of substance, recognizing whether it is pure or mixed with other substances, and separating one substance from other kinds of substances. The chapter did not make any explicit reference to knowledge developed in the first chapter. The concept of solution was then introduced, emphasizing the differences between pure liquid and solution. Vapor presssure was considered an important property of pure liquid, and the change in its value which results from dissolving a substance in liquid allows for the change in the properties of a solution.

Concentration of solutions and the solubility of a substance in another substance were introduced, and numerical examples and problems were used. Electrolytes and non-electrolytes were discussed, showing that molecules of electrolytes form ions when dissolved in water, and through these ions the solution conducts electric current. An extended section of separating the components of solution illustrated the processes of distillation, crystallization, and extraction, the principle on which each process works, and its applciation in practical purposes.

Chapter two ended with a section on colloidal solutions; their composition, formation, properties, and application were mentioned.

Chapter three started with a reference to the conclusions which students developed in the first chapter, indicating that this chapter would expand those conclusions. Dalton's model of atoms was developed to interpret a number of observations, but this chapter illustrated the inadequacy of this model to interpret many of the observations and the need to expand Dalton's model to a new one which happened to perceive the atom as a large universe similar to that of the solar system.

The section on the electrical nature of matter reminded students of their prior knowledge developed in the preparatory level (grades seven through nine) about static and current electricity, reviewing this knoweldge as an introduction to experiments of electrolyte and discharge tubes. Faraday's laws were introduced using numerical examples and arriving at the concept of the electron. Thompason's model of the atom was suggested as a result of these experiements as being more adequate than Dalton's model. But Thompson's model did not live long because of its failure to account for new observation. Rutherford's experiment was then introduced and used to show how the nucleus of the atom was discovered. At this point many new concepts related to the structure of the atom were introduced; proton, neutron, atomic number, isotopes, and various types of chemical bonds were explained. A new model of the atom, Rutherford's model, was used to explain electrical conductivity and heat conductivity.

Chapter three ended with a section on forces of attraction between molecules of a substance which account for the three states of matter: solid, liquid, and gaseous. Van Der Waal's forces were introduced very briefly, and the hydrogen bond was explained and used to interpret the particular properties of water.

Teachers' Guide

Each volume of the textbook has its own teachers' guide. The guide for the second volume dealt with each chapter in the textbook in the following format:

1. the approach, the nature and organization of the chapter, its importance and questions to raise interest in learning its subject;
2. the major objectives;
3. activities and procedures:
   a. description of experiments,
   b. general suggestions about treating certain topics, and
   c. movies, films, or filmstrips available in the audiovisual departments related to the topic;
4. answers and solutions to chapter questions and problems; and
5. additional references and readings in Arabic and in English.

The teachers' guide, however, neither specifies modes of teaching nor suggests certain strategies of presentation of different topics, nor does it provide any suggestions about time distribution. The general suggestions about introducting the chapter and identifying objectives and procedures of doing experiments are left to the teacher to infer what to do, when, how, and within what time frame. To illustrate the importance of the topic and encourage students to attend carefully, the teachers' guide suggests that the teacher raise one or more of eight questions which serve as advanced organizers to establish direct relevance to some background knowledge and facilitate more meaningful learning. The teachers' guide also indicates the reason for not including much detail about the subject matter presented in the text: information about gas laws, properties of gasses, and laws of chemical composition are not goals for their own sakes. The goal in this case is to show the continuous and systematic spirit of inquiry which scientists follow using various activities such as description, experimentation, organization of acquired information, and interpretation. According to the teachers' guide, the teacher is expected to deal with these activities of scientific inquiry explicitly by discussing these activities of sience and relate them to the inductive reasoning explained in the garbage collector analogy (see Appendix G) which was also provided in the teachers' guide.

To show the teacher the line on which knowledge about the structure of matter was built, the teachers' guide expanded the introduction about the nature and purpose of the unit (properties of matter and the particle model) which began the first chapter of the textbook:

> Building the atomic model in this chapter does not follow the historical development of the concept of atom or relies on complicated experiments which need sophisticated equipment; rather it depends on presenting some observations about a certain phenomenon, raising some questions and using simple experiments to answer these questions in order to arrive at appropriate conclusions. Atomic model was suggested first as an inference about the hidden structure of matter. Then the model was developed, refined, and expanded gradually as our knowledge was growing and evidences were accumulating (p. 1).

The instructional objectives of the first three chapters of the unit as specified in the teachers' guide are shown in Table 4-1.

Table 4.1
Goals and Objectives Relevant to the First Three Chapters of Unit Three of the NSC

1. to demonstrate an understanding of the nature of science and the work of scientists:

    a. definition of science

    b. activities of science, description, organization of data, explanation

    c. the temporal nature of scientific conclusions

    d. the differences among laws, theories, and models

    e. using knowledge of chemical composition and properties of gas as sources of information about the structure of matter

    f. appreciate the scientist's efforts

2. to state and explain

    a. laws of chemical composition

    b. laws of gases

    c. Avogadro's hypothesis

    d. principles of the atomic theories of Dalton, Thompson, and Rutherford

3. to differentiate among element, compound, and mixture

4. to recognize and write the chemical symbols of the following elements: hydrogen, oxygen, nitrogen, sodium, carbon, chlorine, mercury, florine, silver, gold, iron, potassium, copper, chrome, calcium, sulfer

5. to write the following chemical formulas and equations

$NH_3 + H_2O$ --NH_4OH

$HCl + H_2O$ -- $H_3O + Cl$

$2NO_2 + H_2O$ -- $HNO_3 + HNO_2$

$Cl_2 + H_2O$ -- $HClO + HCl$

$2H_2 + O_2$ -- $2H_2O$

$2NO + O_2$ -- $2NO_2$

$Na_2S_2O_3 + 2HCl$ -- $2NaCl + SO_2 + H_2O + S$

Table 4.1, continued

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6. To explain and define the following concepts

    a. atom
    b. molecule
    c. element
    d. compound
    e. solution
    f. mole
    g. aqueous solution
    h. Avogadro's number
    i. symbol
    j. molecular formula
    k. structural formula
    l. real gas
    m. ideal gas
    n. relative weight
    o. scientific theory
    p. scientific law
    q. scientific model
    r. endotheric reaction
    s. exothermic reaction
    t. isotopes
    u. atomic mass
    v. atomic number
    w. electron
    y. proton
    z. neutron
    aa. electrolyte
    bb. non-electrolyte
    cc. ion
    dd. molarity
    ee. melting point
    ff. freezing point
    gg. boiling point
    hh. condensation point
    ii. vapor pressure
    jj. atmospheric pressure
    kk. chemical bond
    ll. covalent bond
    mm. metallic bond
    nn. ionic bond
    oo. hydrogen bond
    pp. equilibrium
    rr. solubility
    ss. saturation
    tt. colloidal state
    uu. crystallization
    vv. extraction
    ww. filtration
    xx. distillation

Table 4.1, continued

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zz. petroleum
aaa. liquid air
bbb. alpha particles
ccc. gamma rays
ddd. cathode rays
eee. anode
fff. cathode
ggg. battery
hhh. electro-chemical cell
iii. pure substance
jjj. evaporation
kkk. fractional distillation
lll. Brownian movement
mmm. conductor
nnn. semi-conductor
ooo. electrical conductivity
ppp. heat conductivity

7. to perform calculations related to the mole and molar concentrations

8. to identify the following laboratory equipment and demonstrate their use in the construction of apparatus and conducting experiments: beaker, volumetric flask, bunsen burner, funnel, thermometer, condensor, fractional condensor, test tube, stand, clamp, screen, cathode tubes, discharge tubes, voltmeter, rheostat, sensitive balance, Rumcorff coil, Thompson apparatus, AC-DC electrical transformer

9. to develop some intellectual skills and processes: observing, inferring, establishing relationships

10. to develop the habits of patience and cooperation in conducting experiments

11. to distinguish pure liquid from the solution and draw the curve of changing the state for each of them

12. to use the principles of separating components of a solution in useful, practical applications

13. to recognize the electrical nature of matter and the relationship between matter and electricity

14. to recognize and explain the forces which bind the basic particles inside the atom, atoms in molecules, and molecules with each other

15. to construct models of some molecules such as ammonia and methane

16. to explain some properties of matter using Rutherford's model of the atom

Experiments and Practical Activities of the Course

Doing the experiments and practical activities is considered essential in teaching NSC. Volume I of the textbook emphasizes that:

> The teacher is required to consider the practical activities and experiments' major part of the course. He has to spend needed effort and time to do them or urge the students to do them. Neglecting these practical activities and just talking about them hurts the philosophy of the curriculum and reduces the possibility of achieving expected results (Al-Sheikh et al., 1979, p. 6).

The textbook requires the reader to do certain experiments and asks questions about the reader's observations, without providing direct answers; but the conclusions given in the paragraphs which follows these experiments in the texbook provide indications regarding what students are expected to understand from the experiments. An example is given in the following extract:

> Bring a test tube full of ammonia gas close to another test tube full of hydrogen chloride gas; remove the stopper from each test tube; what do you notice?
> Expose nitrogen oxide to the oxygen of the air; what happens? Compare the gas formed with nitrogen dioxide; try to explain your observation.
> Ignite a matchstick; put out the flame, leaving some fire; insert the matchstick into a test tube full of oxygen. What do you notice?
> Bring a matchstick close to hydrogen gas; explain your observations.
>
> From what you have done, you notice that gases are different from each other in their chemical reactions. Each gas has its own characteristics . . . (the textbook continues explaining what students should conclude based on the experiments) (p. 4).

In other cases, the text provides sufficient clues to answer the questions or explain the observations:

> Heat a solution of sugar in water until it boils; condense the resulting vapor using a distillation apparatus as in Figure 3-2 (see Appendix J). Notice how the solution behaves during boiling. Does the solution boil at the same boiling point as pure water? Does the temperature stay constant while the solution is boiling as it does when pure water boils? Or does it continue to rise? Compare the behavior of pure water and behavior of the solution as represented in Figure 2-4 (see Appendix J). Try to recognize what the arrows in the figure refer to.

Notice that the temperature at which the solution starts boiling is higher than that in the case of pure water. Try to explain that.
You know that pure water boils when its vapor pressure becomes equal to the atmospheric pressure. In the case of the solution, you notice that you raised the temperature to a higher point than the boiling point of pure water. If you remember that . . . (the text continues to explain and answer the questions raised before) (pp. 36-37).

Another way of treating the experiments in the textbook is the way in which the text does not provide an explanation of the observation or answer to questions; help from the teacher is most probably needed in this case. The following extract is an example of this case.

Direct a narrow light beam (passing through a small hole) at a beaker containing real solution and another beaker containing colloidal solution. Compare your observation in both cases.
Direct a narrow light beam at the bottom of a long glass beaker containing hypo solution such that the passing rays will fall on the classroom ceiling. Notice very carefully the color of the falling rays. Add a few drops of hydrochloric solution to the hypo solution. Stir for one moment; wait until the particles of sulfur start forming. Notice the color of the colloidal particles.
Continue following carefully the color of light rays on the ceiling and notice the change in color until the light disappears completely.
How do you explain the previous light phenomenon? (P.S., perform these experiments in a dark room.) (end of chapter two in textbook, p. 69)

There are experiments which are presented in the textbook in a way which does not require the reader to conduct them. Such experiments are presented in two forms. The first is a description of the origianl experiment done by a particular scientist:

In this experiment, Rutherford exposed very thin sheets of some elements to a flow of positively charged alpha particles, after accelerating their velocities, he noticed that the particles are scattered as follows . . . (p. 75).

The second form is a description of an experiment as if someone has been doing it or the way in which it can be done:

If a certain amount of oxygen is mixed with another certain amount of hydrogen . . . (p. 2)

To examine whether there is any change in the amount of solute exceeding the solubility, the following experiment can be performed:

1. a certain amount of ordinary iodine is dissolved in . . . (p. 43).

The experiments and practical activities which the textbook and/or teachers' guide require the teacher to conduct as demonstrations and/or provide the chance for students to conduct are presented in Table 4-2. The textbook does not specify whether the experiments should be done by the teacher or students. The teachers' guide indicated explicitly that experiments in the second chapter were important, easy to conduct, and could be conducted by students using simple equipment; it required the teacher to provide the chance for students to work by themselves individually or in groups. The teachers' guide did not provide any suggestions as to whether experiments in chapters one and three should be done by students or as demonstrations by the teacher.

Presenting Topics in the Curriculum Materials: Two Examples

The concept of vapor pressure and the direction of electron flow were chosen to describe introduction of materials in the textbook and teachers' guide. These two examples were chosen because the teacher in this study, Miss Talib, encountered some problems in teaching them in her classroom, and some data about students' learning are available. The first example seems to be fundamental in the chapter, and it was used in more than one place in the textbook. Eight of 18 questions at the end of the chaptr were related to this concept. The second example did not seem fundamental in the textbook, but the teacher put a substantial emphasis on it during classroom teaching.

Showing the way in which these two concepts were presented in the curriculum materials is expected to serve the analysis and discussion of classroom teaching and student's learning of those concepts.

Table 4.2
Experiments Required by the Textbook and/or Teachers' Guide

Chapter I

1. Properties of gasses
   --colors of gasses, solubility of gasses in water, color of chemical indicator in solutions of gasses, chemical reaction of gasses; text, pp. 3-4; teachers' guide, pp. 10-14
2. Law of conservation of matter; teachers' guide, p. 14

Chapter II

1. Boiling point of pure water; teachers' guide, p. 23
2. Melting point of paradichloropenzene; teachers' guide, pp. 24-28
3. Curve of melting ice; teachers' guide, pp. 28-29
4. Homogeneous solution; text, p. 34
5. Boiling curve of sugar solution; text, p. 36
6. Molar concentration; teachers' guide, pp. 29-30; text, pp. 40-41
7. Supersaturated solution and crystallization; text, p. 47; teachers' guide, pp. 37-39
8. Distinguish electrolytes from non-electrolytes; teachers' guide, pp. 30-32; text. pp. 47-49
9. Extraction; teachers' guide, pp. 32-34
10. Distillation; teachers' guide, pp. 34-36
11. Fractional distillation; teachers' guide; pp. 36-37
12. Electrical conductivity of solutions of various concentration; text, p. 52; teachers' guide, pp. 30-32
13. Colloidal solution; text, p. 64; teachers' guide, pp. 39-41

Chapter III

1. Static electricity; teachers' guide, p. 47
2. Electrolysis, Faraday's experiment; teachers' guide, pp. 47-51
3. Electrochemical cell; teachers' guide; pp. 52-53
4. Electrical conductivity of various substances; teachers' guide, pp. 53-54
5. Discharged tubes and properties of cathode rays; teachers' guide, pp. 51-52
6. Models of molecules: CH_4, CO_2, C_2H_4, C_2H_2, N_2, O_2, H_2; teachers' guide, p. 54
7. Model of atoms: H, He, Na; teachers' guide, p. 55

Vapor Pressure

The textbook introduced the concept under a subtitle "Vapor pressure--equilibrium between the liquid and its vapor" under the main title of "properties of pure substance" in Chapter Two. It begins:

> A little while ago we considered that liquid changes into vapor at the boiling point of liquid. But liquid evaporates at all temperatures. Evaporation rate increases as temperature is increased. The pressure exerted by the molecules of vapor of the liquid over that liquid is called the vapor pressure of the liquid.
>
> Each liquid has a certain vapor pressure which depends on the kind of liquid and on temperature (p. 32).

The underlined statement was printed in the textbook in blue. Parallel to these three statements in the margin of the same page are two statements, also printed in blue. They read as follows:

> Liquid vaporizes at all temperatures, the vapor resulting from this process generates a pressure called the vapor pressure of the liquid at a certain temperature.
>
> Vapor pressure depends on the kind of the liquid and the temperature.

Then the textbook explains the dynamic equiplibrium between the liquid and its vapor in a closed system, when the atmosphere over the liquid becomes saturated, and relates it to the concept of boiling. Values of vapor pressure of water and ethyl alcohol at temperatures of 20, 40, and 100 degrees celsius were compared to account for the fact that ethyl alcohol boils at a lower temperature than water. Finally, it concluded that the pure substance is characterized by three properties: melting point, boiling point, and saturated vapor pressure.

All these ideas were paraphrased and printed again in blue on the margin of the same page.

The concept of vapor pressure was brought up again during discussion of the behavior of solutions during boiling (pp. 36-37) to account for the fact that solutions boil at a higher degree than pure liquid and that temperature does not stay constant during the boiling of solutions; it continues to rise.

The knowledge regarding the concept of vapor pressure addressed in these places and required for students to know in order to be able to answer chapter questions is summarized in the following propositions.

1. Each pure substance has, as a specific property, a certain vapor pressure.

2. Liquid evaporates at all temperatures.

3. Evaporation rate increases as temperature is increased.

4. The pressure created by the molecules of vapor over the liquid is called the vapor pressure of that liquid.

5. Vapor pressure traped over liquid in a closed container becomes constant when the space over the liquid becomes saturated by vapor.

6. Dynamic equilibrium between the liquid and its vapor is produced when the space over the liquid is saturated with its vapor.

7. Vapor pressure of a certain liquid increases as temperature is increased.

8. Vapor pressure becomes constant when it reaches the amount of atmospheric pressure.

9. The boiling point of a liquid is the point where the vapor pressure becomes equal to atmospheric pressure.

10. If vapor pressure of a certain liquid (A) is higher than vapor pressure of another liquid (B) at a certain temperature, then the boiling point of A will be lower than that of B.

11. Pure ethyl alcohol has a higher vapor pressure than water, so it boils at a lower temperature.

12. The vapor pressure of a solution is lower than that of a pure liquid.

13. The boiling point of a solution is higher than that of a pure liquid because the solution has a lower vapor pressure than pure liquid.

As mentioned earlier the teachers' guide does not provide any suggestion in dealing with specific topics. The concept of vapor pressure was referred to in the teachers' guide in the following instances:

1. as a new concept to be learned under the objectives of the chapter;

2. "students are expected to conduct the experiment in section 2:3:1 in the textbook and to follow the procedures described in the textbook" (p. 23). The experiment deals with the behavior of a

solution during heating. Students are expected to answer the question in that section where the concept of vapor pressure shoudl be employed;

3. students are expected to conduct the experiment in section 2:1:2 about boiling pure water. The procedurs of doing this experiemtn were presented in the teachers' guide in some detail. Several questions were provided including a question about the fact that the boiling point of water is expected to be lower than 100 C. The reason given was that the vapor pressure of water at that particular altitude will be equal to atmospheric pressure which should be less than 760 mm; and

4. the answers to eight questions at the end of chapter two in the textbook which include the use of the concept of vapor pressure were provided in a similar way to that mentioned in the textbook itself. All the knowledge addressed in these answers was included in the list of propositions mentioned earlier.

Direction of Electron Flow

The topic in this example was electrical conductivity and its explanation in terms using knowledge learned from the structure of matter after the development of Rutherford's model of the atom. One and one-half pages of the textbook were devoted to explaining how static electrical charges are formed by friction on plastic and glass when they are rubbed with wood and silk, respectively, and how these charges are discharged. Chemical reaction in an electrochemical cell (battery) was given as another source of the formation of electrons. When the two terminals of the battery are connected to each other by a conductor, electrons flow from the terminal where they accumulated in large numbers (called the negative terminal) to the terminal which has a shortage in electrons (called the positive terminal). The conducting wire can facilitate the flow of electrons because it has mobile electrons in its atoms which can be pushed in a certain direction forming an electrical current. The propositions related to this topic as presented in the textbook were the following:

—chemical reaction is a source of accumulating electrical charges

--mobile electrons in metals such as copper and silver can move in a certain direction if subjected to some force

--the battery is the source of electrons which accumulate on the negative electrode

--the negative electrode has plenty of electrons which are ready to be given away

--the positive electrode has a shortage of electrons and are ready to accept them

--if the two electrodes in a battery are connected by a conductor, a potential difference causes electrical current to flow

--if a bulb is connected to the conductor, it will glow

--the battery provides substitute electrons to the negative electrode to keep the electrical current flowing

--the battery does the work of a pump in pushing electrons in the direction of the current

--if a galvanometer is connected to the conductor, the needle of the galvanometer will move, indicating the passage of current

--the battery is similar to a pump which pumps electrons from the negative electrode ot the positive electrode (pp. 87-88)

Nothing in the teachers' guide was related to the direction of electron flow except one instance where a battery is expected to be opened "to identify its components and to know that these components are the source of the electrical current (the electrons)" (p. 47). However, electrification and electrical conductivity were listed as new concepts to be learned under the objectives of the chapter.

In brief, the Natural Science Course for students of the tenth grade was designed in 1970, when the syllabus and guidelines related to the concent and methods of presentation were approved by the Board of Education. The syllabus and guidelines were included in the Science Curriculum Pamphlet for the Secondary School. The first printing of the textbook appeared in 1974, and teachers began to use it in their classrooms at that time. The first printing of the teachers' guide appeared in 1976.

The purpose of introducing unit three of NSC (properties of matter and the particle model) was to help students explain the natural phenomena which are related to the properties and structure of matter and to recognize the laws which control the behaviors and changes of matter. Understanding of the nature of science and the development of scientific skills and attitudes were emphasized as important objectives for students to acquire.

The organization, conceptual content, and practical activities and experiments of the first three chapters of the unit in the textbook and teachers' guide were described in order ot provide a base for the following analysis of teaching activities and students' learning outcomes.

Analysis of Teaching Activities

Introduction

One of the slogans frequently used by the administrators in the Ministry of Education in Jordan was "elements of the educational process are planning, implementation, and evaluation." In this part of the analysis, the researcher has addressed Miss Talib's teaching activities in light of these three elements.

It is assumed here that the teacher starts his/her teaching activities before entering the classroom by thinking why, what, and how s/he is going to teach. In other words, s/he makes a plan. In the classroom the teacher uses some instructional strategies to implement that plan. At various points during classroom teaching, at least toward the end, the teacher gets some data about how effective those plans were. There are three phases--planning, implementing, and evaluating--that comprise the major components of any teaching act. There is continuity and interrelationship among the phases; each has influence on and is influenced by the others.

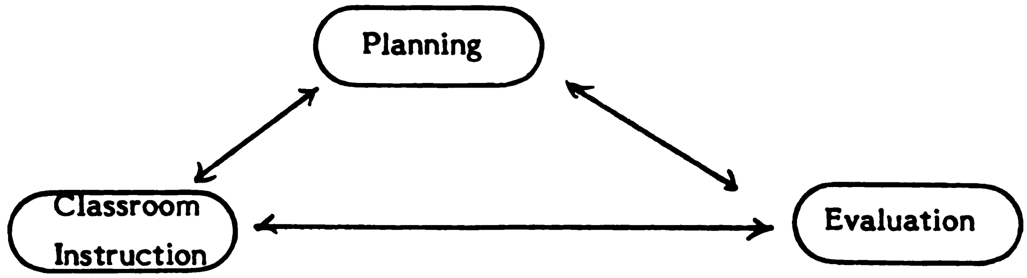

Figure 4.2. Continuity and interrelationships among phases of teaching.

In the following sections, attempts were made to look at these three phases in Miss Talib's case, teaching natural science in a tenth grade classroom at Northeastern Secondary School.

Planning

In an interview with the Northeastern Secondary School's principal, she classified teachers into three categories as far as planning is concerned:

1. those who write their plans in a meaningless way because it is something officially required,
2. those who write good plans and believe in their importance, and
3. those who do not write any planning and do not believe in its importance.

She also noticed that most teachers have negative views of planning and that more experienced teacher give better attention to planning, and that all teachers do not carry their planning books to their classrooms because they consider this "a sign of their inability to remember and a sign of not sufficient preparation" (Interview with principal, February 9).

According to the principal's judgment, Miss Talib falls into the first category.

Miss Talib prepared her own yearly plan at the beginning of the school year, and she writes her lesson plans in a planning book; nevertheless, she has a negative attitude toward planning in its official meaning. She writes down lesson plans because it is required. According to her own description:

> The lesson plan has a general goal which is the same and is repeated in each plan. To acquire the basic information required to understand and explain natural phenomena, understand the nature of science, develop scientific attitude and intellectual and psychomotor skills. Then I choose three or four specific objectives of the lesson, I cannot write all the objectives because the space provided for them in each page of the planning book is very small . . . . I do not always write the lesson plan before the lesson; it is possible to write it after I give the lesson. Of course, they assume that it should be written before; I say there is no difference to write it before or after.
>
> Interviewer: If it is required to be written before, why do you write it after?
>
> Miss Talib: Because it is required from me to write anyway. Sometimes I use a certain activity or procedure during the lesson which comes to my mind accidently. I put this in the lesson plan (when I write it after the lesson). This will help me if I teach the lesson for another section or next year.
>
> Interviewer: Whatever procedures of writing the lesson plan might be, how do you prepare yourself to teach a topic?
>
> Miss Talib: I read the topic in the textbook; sometimes I use a paper and pencil, sometimes not. I do not break down the topic into parts or put marks in my textbook, but everything is mentioned during the lesson according to the same sequence presented in the text. I try to find the relationship of the topic with what is relevant to it in previous topics. If something is not clear, I try to make it clear for myself. If a number is mentioned and I do not know where it came from, I take a paper and a pencil to see where it came from. It is not always necessary to carry a pencil. It is possible to prepare while the TV is on (second interview, March 1).

Thinking about the practical activities and experiments that should be conducted in the following lesson is part of the planning activity. This requires the teacher to know what is available in the school laboratory and to try the experiment before the lesson. Since there is no free time for teachers except after the school day, this represents another burden. In presenting ways in which a separation funnel is used to separate liquids, one student suggested that it be demonstrated in class; the teacher responded to this suggestion by saying that most probably the lab did not have a separation funnel. At a later date, she took the researcher to visit the lab where she realized that there was more than one funnel there.

Appendices L and M show samples of Miss Talib's lesson plans. Under the activities' aids and procedures, the teacher listed the following:

1. perform simple experiments on static electricity,
2. demonstrate an electrical cell and recognize its components,
3. explain Faraday's laws, and
4. conduct the experiment of electrolysis if possible (Appendix Lb).

In the actual lesson, she talked about these experiments, but did not do any of them. In a later interview, she was asked why she did not do that; the answer was, "These experiments are simple and well known; why waste time on them. And the electrolysis experiment is impossible to work."

The experience of the researcher in teaching and teacher education in Jordan for 12 years reminds him of the anxiety that teachers and student teachers feel when the word "planning" is mentioned. Almost all teacher will agree that planning is the first logical phase of any teaching, but most teachers feel that requiring a specific method of planning and writing down that plan is a burden which they do not like.

> Supervisor: She will tell you, "I do not deny that planning is very important," and she will swear that she never goes into a classroom without preparation; but her argument goes like this, "I prepare in order to know why, what, and how I am going to teach the next lesson in a certain class, so it is part of my own business which I do in my own way. When you require me to write this plan in a certain planning book in a certain model which is defined by those at the top, in order that the principal and supervisor will see and sign that they have seen this on such

and such a date, the planning at this point becomes something for them and does not below to me."
Teacher: Tell me, honestly, is that not right?
Audience: (laugh)

(Informal discussion in the principal's office during the school activity day, March 10, fieldnotes.)

The Actual Classroom Instruction

Lesson Format

Assuming that all topics of natural science course, volume two, will be covered during the second semester, unit three could be reasonably covered in eight-nine weeks (32-36 periods of 45 minutes each). Table 4.3 shows the distribution of topics covered during the period of observation in the present study. Twenty-six periods were spent in teaching the three chapters in the unit.

The usual classroom of the first secondary class, section one, was the place where instructional activities occurred in 25 periods. Period 3-3 was spent in the school lab. Five periods were spent in doing the pre- and posttests of three chapters. At least one period was spent in reviewing each chapter through; answering the chapter questions.

Verbal communication, "talk and chalk," was the main method of presentation during all periods. The only instances where the teacher used something else were the following: (a) teacher demonstrated passing electrical current through discharged tubes of neon, argon, and nitrogen gasses; (b) teacher showed a model of the solar system to demonstrate Rutherford's model of atoms; (c) teacher showed small balls of plasticine to represent atoms with sticks to represent chemical covalent bonds; (d) students read from the textbook and teacher made comments in one lesson; and (e) teacher assigned the responsibility of presenting new topics to two students. Even in the last instance, teacher talk was dominant because she made comments or clarification on what the first

Table 4.3.
The Lessons Observed During the Period of the Study

Number	Date	Topics Covered	Form of Recorded Data
1-1	1/27	Pretest, Chapter 1	SR, FN
1-2	1/28	Introduction, gas laws, properties of gases	FN, AT
1-3	1/31	Laws of chemical composition	FN, AT
1-4	2/2	Dalton's atom, Avagadro's hypothesis	FN, AT
1-5	2/3	Ideal gas, review	FN, AT
1-6	2/4	Review, chapter questions	FN, AT
1-7	2/7	Posttest, Chapter 1	FN, AT, SR
2-1	2/9	States of matter, melting and boiling points	FN, AT
2-2	2/10	Vapor pressure	FN, AT, VT
2-3	2/11	Behavior of solution	FN, AT, VT
2-4	2/14	Molarity	FN, AT, VT
2-5	2/16	Solubility	FN, AT, VT
2-6	2/17	Electrolytes and non-electrolytes	FN, AT, VT
2-7	2/18	Separation of solution's components	FN, AT
2-8	2/22	Fractional distillation	FN, AT, VT
2-9	2/23	Colloidal state	FN, AT, VT
2-10	2/24	Review of chapter questions	FN, AT, VT
2-11	2/25	Posttest of Chapter 2	FN, SR
3-1	3/1	Pretest of Chapter 3	FN, SR
3-2	3/2	Expanding atomic model	FN, VT
3-3	3/3	Lab, electrical discharge	FN, VT
3-4	3/4	Rutherford experiment	FN, AT
3-5	3/8	Forces between atoms	FN, AT, VT
3-6	3/9	Explanation of conductivity	FN, AT, VT
3-7	3/11	Hydrogen bond; chapter review	FN, AT
3-8	3/15	Posttest of Chapter 3	SR

Key to Forms of Recorded Data

FN:	Field notes
AT:	Audiotape
VT:	Videotape
SR:	Student responses on text

student had to say or helped the students in situations where she was not able to state the correct information. The second students felt anxiety and tension in being in the place of the teacher and was not able to do the presentation; the teacher took over the situation and pursued her role as usual.

At the end of each period, the teacher assigned certain pages to be prepared as homework. During the next period, she discussed the topics on those pages using lecture and question/answer approach where questions from the teacher solicit student responses as far as students were able to understand their reading of the textbook at home. Textbooks were expected to be closed during the lesson.

After observing the 26 lessons, the researcher found very little evidence of of the existence of a clear base to classify the lessons into certain categories. Miss Talib did not recognize many differences among lessons except in the quality of the students' preparation at home. The lessons went more smoothly and there was a better chance of students' understanding the topic if they were well prepared. Periods of tests could be distinguished, however, as a separate format "because they are not periods of instruction; they are periods of evaluation." There were also slight differences between a typical lesson in which the teacher presented a new topic and periods in which some numerical problems were solved or chapter questions were answered. When the teacher assigned the role of presenting the new topic to a certain student, the kind of classroom interaction was different from that in a typical lesson. The lesson which was given in the laboratory where some demonstrations were conducted was also different in the type of classroom interaction. Table 4-4 shows the distribution of the 26 periods in six formats. The analysis presented in the following section is related to the 21 periods devoted to teaching. The five periods of testing are excluded for the time being, and student responses on tests will be analyzed later in this chapter.

Table 4.4
Formats of Periods of Observation

	The Lesson Format	Code	Number of Periods
1.	Typical lesson, presentation of new topic	TYP	14
2.	Problems solved and chapter questions answered	REV	4
3.	Student presentation	STUD.P	1
4.	Reading aloud from textbook	READ.B	1
5.	Laboratory session	LAB	1
6.	Test	TEST	5
	TOTAL:		26

The Flow of Events in a Typical Lesson

A typical lesson in Miss Talib's classroom usually is the lesson in which the teacher "gives" a new topic. Unless it is a special visit for a certain goal, a science supervisor plans to visit the teacher during a typical lesson. Even the teacher does not like to be visited in lessons of review or when answering chapter questions. Lesson plans of typical lessons are expected to be written in preparation books. The teacher's performance in such a lesson is expected to be a good representation of her mastery of subject matter and teaching skills. The researcher did not attend one lesson in the second chapter; the next day Miss Talib told him, "You missed nothing yesterday; we just solved some problems on molarity." In another instance, the researcher asked, "What is the lesson about today?" and she answered, "It is a usual lesson; I am going to give them . . . I want to continue separation of solutions' components."

A typical lesson in Miss Talib's classrooms starts approximately one minute after the bell rings if there is no videotaping, or after setting the camera (usually three minutes). Before the teacher enters the classroom, a student cleans the board, writes the day's date in the upper right hand corner, the course name (natural science) in the upper middle of the board, and the topic's name on the right hand side. The teacher enters the classroom and greets the students ("Good morning"). The students stand up as a traditional sign of respect for the teacher, and the teacher will wave her hand for students to sit down or she will say, "In your places."

If the lesson is not the first one in the chapter, the teacher will ask the students to close their textbooks and then refer to the main topic of the last period, making a quick review by asking several questions. The teacher has her own copy of the textbook. She opens it and turns it over on her desk. She then refers to the main topic of the present lesson and starts her questions, assuming that students have read the assigned homework. She restates or paraphrases the correct responses, correcting the incorrect ones, and using the chalkboard to write some important information or drawing some figures and making calculations. Students will copy in their notebooks what is written or drawn on the board. Before leaving one topic for another, the teacher tries to make sure that students have understood the previous one by asking, "Have you understood well oh, first?"* Most probably the students will respond in chorus, "Yes, miss." Then she will ask the question in another way, "Does anyone have any question?" Students usually do not respond.

Students sitting in their assigned places, two at each desk, are shown in Figure 3.1. A student stands up when answering a question or directing a question to the teacher. Miss Talib never sits at her desk; she always moves, most of her movement along one of three lines in Figure 4.3.

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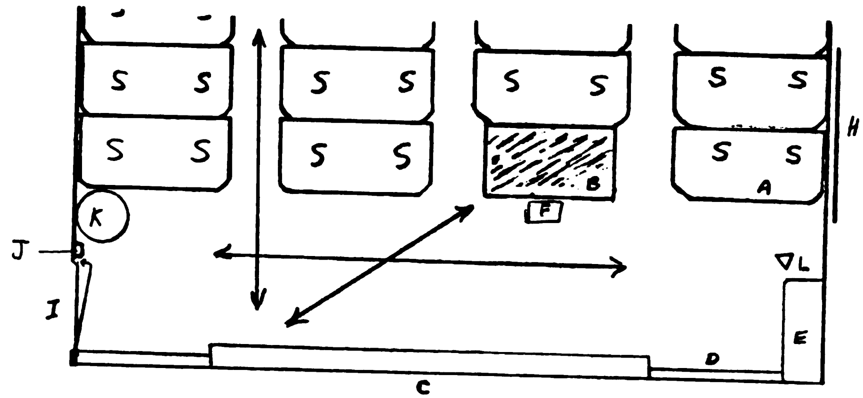
*By "first" she means "first secondary class."



Key:
A Student desks
B Teacher's desk
C Chalkboard
D Bulletin board
E Book shelves
F Teacher's chair
G Coat hangers
H Windows
I Door
J First aid
K Waste basket
L Camera positions

Figure 4.3. Directions of teacher's movement.

One major feature of Miss Talib's classroom was the high frequency of mixed choral responses of a relatively large number of students, as a spontaneous response to a question from the teacher or accompanying the teacher's response of her own question. More than one-half of the total number of teacher's questions were of this type. About one-third of the questions were assigned to students without calling names; the remaining questions were assigned to students by calling names.

There was occasional seat work in Miss Talib's class. When the topic of the lesson had numerical problems, the teacher gave an example or dictated a problem to the students to be written and solved in their notebooks, then picked a student to solve the problem on the board while explaining it orally. Students took notes in their notebooks, including drawing anything the teacher put on the chalkboard, and solved numerical problems and answered chapter questions there.

Toward the end of the lesson, a few minutes before the bell rang or immediately after it rang, the teacher opened her textbook and assigned homework, such as, "Prepare, oh, first, for the next period topics x, y, etc., until the end of the page . . . " Page assignments seemed an important routine for students. At the end of lesson 2-5 (solubility), the teacher told students to prepare the next topic and named it "electrolytes and non-electrolytes." Several students were heard to be asking "until where should we prepare?" The teacher heard them and answered, "Up to the beginning of page . . . " She might add, "Answer questions 1-4 from the chapter questions at the end of the chapter," "Write down in your notebooks: explain the kinds of chemical bonds in the following: chlorine molecule, water molecule, aluminum atoms . . ." "Write the answers in your notebook," or "Write the answers on a separate paper to be handed to me."

The step of reviewing the last lesson and announcing the topic of the present one is usually called the introduction and lasted for 1-5 minutes, the bulk of the lesson is called the presentation, and the final step is the conclusion or evaluation which is, in fact, assigning homework and took 1-2 minutes.

Understanding Classroom Interaction

Various moves and processes of classroom interaction might be seen as similar to those in other social settings, such as business, religious and industrial institutions. Communicative processes are always governed by certain goals and rules. Classroom interaction, however, is characterized by the uniqueness of its own patterns and functions (Barker, 1982).

The dynamic nature of classroom interaction is a result of various components and levels of communication which make the classroom a complex setting and a difficult object for study. Understanding classroom interaction is an essential goal of education because the central assumption on which education has been built during the history of human life is that various aspects of classroom interaction have a great impact on the total personality of the individual and on society in the long run. In studying classroom interaction, the quantity and quality of involvement of various participants in the classroom environment should be taken into consideration. Language usually is the main instrument of communication in classroom interaction. More than 80 systems of classroom interaction analysis were developed, but they all depend on similar foundations. Most of them deal with the verbal aspect of interaction. Flanders' Interaction Analysis Categories (FIAC) system, for example, was developed on the assumption that verbal behavior of an individual is an adequate sample of his/her total behavior and that verbal behavior can be observed with a highly reliable degree (Amidon & Hough, 1967). FIAC is the best known and most widely used system because of its simplicity and flexibility to be used for various aspects and patterns of information. FIAC was employed in some parts of this section.

However, FIAC as well as other quantitative observational instruments has several limitations, especially if it were used as the only source of evidence in making judgments about the effectiveness of teahcing. FIAC was used here as a convenient tool for breaking down the verbal communication of a classroom into major categories, then to investigate some of these categories using the various sources of qualitative data which are available in this study.

Flanders' system catagorized the verbal behavior of a classroom into 10 categories:

1. teacher accepts feeling of students (T. accepts f.),
2. teacher praises or encourages students (T. praises),
3. teacher accepts or uses students' ideas (T. accepts id.),

4. teacher asks questions (T. questions),
5. teacher lectures (T. lectures),
6. teacher gives directions (T. directs.),
7. teacher criticizes or justifies authority (T. criticizes),
8. students respond to teacher soliciting (S. respond),
9. students initiate talking (S. initiate), and
10. silence or confusion in which interaction cannot be understood (sil.).

Applying the necessary steps and ground rules described by Flanders (1970), eight lessons were chosen to be analyzed, representing verbal interaction in various formats of lessons in Miss Talib's classroom. The number of lessons analyzed in each format are shown in Table 4.5.

Table 4.5
Format and Number of Lessons Analyzed Using FIAC System

Lesson Format	Number of Lesson
Typical	3
Review and problem solving	2
Student presentation	1
Reading aloud	1
Lab	1
TOTAL:	8

Percentage of time spent in each category of verbal interaction in these eight lessons is shown in Table 4.6.

Percentages of teacher's talk, students' talk, and lost time are shown in Table 4.7.

It is obvious that the teacher's talk dominates most of the time of any period, especially in a typical lesson where students have very limited opportunity to talk (8.23% of the time) and the teacher does not waste any time.

Table 4.6
Time in FIAC Categories in Various Lesson Formats

Lesson Format	% of FIAC Categories 1	2	3	4	5	6	7	8	9	10	TOTAL
Stud.Pres.	0.48	0.12	11.15	11.15	48.08	2.52	0.84	7.31	5.40	12.95	100
Read.Aloud	0.0	0.0	5.15	1.8	48.96	4.73	0.14	36.02	2.09	1.11	100
Lab	0.60	0.0	4.80	4.07	54.37	4.67	0.48	2.51	1.44	27.07	100
Review and Prob.Solv.(1)	1.07	0.0	10.73	14.60	44.64	4.08	2.79	9.87	3.86	8.37	100
Review and Prob.Solv.(2)	0.0	0.62	6.15	8.62	31.23	17.23	3.69	5.54	4.77	22.15	100
$\frac{1+2}{2}$	0.45	0.36	8.06	11.11	37.72	10.74	3.32	7.35	4.40	16.40	100
Typical (a)	0.0	0.11	13.28	14.30	48.13	1.59	1.02	10.78	0.91	9.88	100
Typical (b)	0.0	0.38	8.23	9.87	66.84	2.66	1.66	5.70	0.51	4.94	100
Typical (c)	0.25	0.25	7.01	9.95	70.76	2.3	1.66	6.25	0.13	1.53	100
$\frac{a+b+c}{3}$	0.08	0.24	9.65	11.36	61.34	2.20	1.30	7.70	0.53	5.62	100

<u>FIAC Categories</u>

(1) T. Accepts feeling
(2) T. Praises
(3) T. Accepts Ideas
(4) T. Questions
(5) T. Lectures
(6) T. Directs
(7) T. Criticizes
(8) S. Respond
(9) S. Initiate
(10) Silence or confusion

Table 4.7
Percentages of Teacher Talk, Student Talk, and "Lost Time"*
in Various Lesson Formats

Format	% of Teacher Talk Sum of Categories 1-7	% of Student Talk Sum of Categories 8-9	Lost Time Category 10
Stud. Pres.	74.34	12.71	12.95
Review and Problem Solve	60.77	38.11	1.11
Lab	68.98	3.95	27.07
Read. Aloud	71.86	11.74	16.40
Typical	86.15	8.23	5.62

*While waiting for students to finish copying the solution of a problem from the board, Miss Talib asked them to "hurry up; we do not want to lose time in copying. The important thing is to understand how we solved the problem; then you should be able to solve it yourselves at home" (in lessons 1-6).

The 5.62% shown under lost time is, in fact, the periods of silence when the teacher is busy in drawing or writing something on the board or when the teacher or a student is clearing the board. It is surprising also that even in periods of answering the chapter questions or solving numerical problems, the chances for students to talk are few (11.74%). A relatively large percentage (22.15%) of lost time is shown in the period of solving numerical problems (Review and Problem Solving 2). Most of this time, in fact, was spent while students were copying the right solution to a problem from the board to their notebooks or in cleaning the board.

The total 42 minutes spent in the lab lesson was distributed into two portions. The first 25 minutes were spent in presenting Faraday's second law, the same mode as in a typical period. The rest of the period, 17 minutes, was spent with students watching the demonstration. Most of the lost time (27.07%)

was lost waiting for the demonstration to work. It was necessary to adjust the screw of the Rumcorff coil several times during the demonstration. The rest of the lost time was spent while changing a gas tube in the electrical circuit for another. Since the connecting wires used in the demonstration did not have crocodile clips, the teacher, with the help of the lab secretary, had to enter the wire terminal with a small ring at each end of the gas tube and fold the wire firmly.

It is clear that a high percentage of students talk in the reading aloud period was a result of the teacher's calling on students to read aloud from the text. Even in this case, the teacher's talk still dominates (60.77%), while lost time was negligible (1.11%).

Table 4.8 represents the interaction analysis matrix of verbal interaction in a typical lesson where the teacher's talk is closest to the average in typical lessons. Teacher's talk in this lesson is 88.86%. FIAC matrices for lessons from other formats are provided in Appendix G. Most of this time (75.21%) was spent in lecturing, 10.68% was spent in asking questions, and 9.26% was spent in repeating, clarifying, and developing student ideas.

There was no instance where the teacher accepted the students' feelings, and only three instances (nine seconds) where she praised the students. There were few instances (1.66%) of criticism and little more (2.66%) of giving directions. Student talk in this particular lesson was mainly (91.84%) responses to teacher questions with only four instances (8.16%) of student's initiation.

From viewing the tape of this particular lesson and turning one's attention to the quality of teacher talk and student talk, it was possible to recognize certain patterns of classroom verbal communication. The content of instruction was broken into a chain of propositions, most of them followed by rhetorical questions. The content of the rhetorical questions was usually either the same

Table 4.8
FIAC Interaction Analysis Matrix of Lesson 2-3

	1	2	3	4	5	6	7	8	9	10	TOTAL	%
1											0	0.0
2				1	2						3	0.38
3			22	8	26	2			1	6	65	8.23
4				33	2	2		36	1	1	75	9.87
5		3	1	30	466	3			2	23	528	66.84
6				3	4	9	2	1		2	21	2.66
7						1	6	2		1	10	1.66
8			37		2			5		1	45	5.70
9			3		1						4	0.51
10			2		25	4	2			5	39	4.94
T	0	3	65	75	528	21	10	45	4	39	790	100
%	0	0.38	8.23	9.87	66.84	2.66	1.66	5.70	0.51	4.94	100	

content as the previous proposition or the completion of the present one. In both cases, the answers were given by students spontaneously in a mixed choral responses. Students' choral responses are mixed with teacher's responses in most cases. Students' correct repsonses are also mixed with incorrect responses very often. The teacher clearly expected students to know the answers. A gesture of surprise and objection was shown on the teacher's face whenever an incorrect response was given by the class or by one or more of the students (if the incorrect response could be recognized at all over the noise of the choral response). The teacher usually responded to the same rhetorical questions and her voice was mixed with the chorus.

The following extract from this lesson (2-3) represents the mode of choral response to rhetorical questions:

T: The second result is that boiling point of a solution does not stay constant while the substance is boiling (she wrote this statement on the board). So the temperature did not . . .
Ss: stay constant
T: during
T & Ss: boiling
T: it continued
T & Ss: rising up
T: I will represent these results for both . . .
T & Ss: the solution
T: and
T & Ss: the pure water
T: the kind of representation is called
T & Ss: graphic representation
T: I make two axis, X and
T & Ss: Y
T: X represents
T & Ss: time
T: time measured in
T & Ss: minutes
T: Y represents
T & Ss: temperature
T: temperature measured in
T & Ss: Celsius

Miss Talib solicits these mixed responses intentionally most of the time. She expects these responses and waits for them. Sometimes she speaks slowly so that students will catch some phrases or words at the end of her statement. Other times she stops speaking, waiting for the students to utter the word or phrase she was about to utter or write on the board. She might also write on the board or refer to something already written that which she expects the students to mention in chorus. Students seem motivated by these mixed responses. The teacher feels that this practice indicates a clue of paying attention and following along with the instruction. The students and teacher get the impression that everything is well understood.

After spending considerable time in presenting the relationship between vapor pressures and boiling points of water and ethyl alcohol, the teacher called on a student to answer a question about which one of them should have higher vapor pressure. The student answered incorrectly, so the teacher gave more illustration and repeated the same question, calling on another student to answer. The second student answered incorrectly, too. At this point, Miss Talib provided more illustration with a higher voice and impatient gestures, soliciting the required responses inspired and guided by rhetorical questions. At the end of this segment of instruction, she asked the traditional question--whether the students understood or not--and the students answered positively as usual.

The following extract from lesson 2-2 illustrates this very clearly.

T: Which one has higher vapor pressure, water or ethyl alcohol? Yes? (pointing to a student)
S: Water.
Ss: No!
T: Why? Suppose that we heated water to the boiling point. Water reached the boiling point at 100 C; alcohol at 78.5 C at the atmospheric pressure. Which is higher, the vapor pressure of water or alcohol?
(No hands were raised.)
Both of them reached . . . (She pointed to the number 760 on the board.)
T & Ss: 760 mm
T: But I was able to boil ethyl alcohol at 78.5 C; water at what degree?
T & Ss: 100 C
T: So who has higher vapor pressure, water or ethyl alcohol?
(Few hands were raised, and the teacher picked one of the students.)
S: Water.
Ss: (noises) No, miss . . .
T: I need to raise the temperature to 100 C. But for this (ethyl alcohol), I need to raise the temperature only to 78.5 C. What should it (vapor pressure) be--higher or lower?
Ss: Higher.
T & Ss: Higher.
T: This (ethyl alcohol) should have much higher (vapor pressure)? So the vapor pressure of ethyl alcohol is . . .
T & Ss: Higher than the vapor pressure of water.
T: Why? Because I need to get them to reach the same pressure in order for them to boil at sea level, and vapor pressure depends on what?
T & Ss: temperature
T: For this ethyl alcohol, I do not need high temperature, so its pressure is originally . . .
T & Ss: high

T: But what about the pressure of this (water)?
T & Ss: low
T: So I need more temperature to get it to reach the pressure of 760 mm. Is there any question on vapor pressure?
(no response)
On the melting point?
(no response)
Is everything understood?
Ss: Yes.
T: Erase (the board)
(While one student from a front desk cleaned the board, the teacher started a new topic, saying, "Let us start to distinguish between pure substance and the solution.")

The teacher herself was not even sure about her own understanding of this problem. In answering one of the chapter questions related to the same problem, she accepted an incorrect response from a student and moved to the next question. But a student, "Rana S.," was not satisfied and questioned the incorrect response. The teacher asked her opinion of the right answer, and she gave the correct answer. At this point, the teacher asked the researcher to clarify the situation, and he did. Students' responses to question 30 in the posttest at the end of the chapter also provides mixed evidence about how much they have learned. Thirty-three of 53 answered a question of similar type incorrectly; six students of them are among the higher achievers.

Toward the end of lesson 2-6 and after the teacher has finished teaching the factors that affect the solubility, she asked her traditional question, "Does any of you have any questions?" There was no response. She addressed the class: "Tomorrow, if I bring a question on solubility, half of you will not answer it."

The teacher sometimes asks a rhetorical question to a particular student even if the question has already been answered by the class. The reason in this case is either to draw the attention of that particular student to participate or put some emphasis on the content of the questions.

It is interesting to note that students in most cases can distinguish between questions which need spontaneous answers in chorus and questions which need answers of individual students.

T: Clean the board. We will start studying the concentration of solution. We start with cups of sugar solutions, two identical cups. In the first we dissolved one spoon of sugar and in the second we dissolved two spoons of sugar. Which of these cups is sweeter? (She pointed to a student without calling her name.)
S: The one with more sugar.
T: Why are two spoons of sugar in a cup of water sweeter than one spoon of sugar in a cup of the same size? (She picked a student without calling her name.)
S: Because the molecules of sugar in the second cup are more.
T: You depended on the quantity of the sugar. (She wrote on the board "the quantity of sugar.") The quantity of sugar affects the sweetness of the solution. A jar and small cup each full of water. I dissolved one spoon of sugar in each of them. Which one is sweeter? The solution in the cup will be sweeter than that in the jar. What is the difference here? The quantity of water. So in one case the solute, sugar, is different; in another case, the quantity of water is different. What do I call this solution?
S: (Picked by the teacher without calling name.) Concentrated solution.
Ss: (noises) Aqueous solution.
T: Aqueous solution. This proportion between the quantity of water and the quantity of sugar I will call the concentration of solution. Take two beakers of the same volume. (She drew two beakers on the board.) Each one has one litre of water. I dissolved 100 gm of sugar in the first and 100 gm of water in the second. (She wrote sugar in the first and water in the second.)
Ss: (noises, but not clear)
T: (After looking at the class, repeated the last statement.)
S: Miss, the second should have sugar, not water.
T: (Teacher noticed the error and changed the word water in the second beaker to salt.) This is salt. Is the proportion of sugar in water the same as the proportion of salt in water?
Ss: (Mixed whispers.)
T: We come back to Avogadro's hypotheses.
Ss: (Mixed whispers.)
T: The number of molecules is different. I have to consider the concentration of the solution which means the number of molecules of sugar in water and the number of molecules of salt in water. (The last statement is repeated by the teacher.) What did Avogadro say?
Ss: (Whispers and movements.)
T: What did he say, Majida?
M: (Silence.)
T: (Addressing all the class) What is the problem, class? Would you like me to give an exam? Or what? (The teacher picked another student by pointing to her and saying, "Yes?")

S: Equal volumes of different gases have the same number of molecules.
T & Ss: Equal volumes have the same number of molecules.
T: Here do we have the same number of molecules?
Ss: No.
T: I will see what is the number of molecules of sugar in one litre and the number of molecules of salt in the other. I have to go back to the mole. How many molecules in one mole?
Ss: Avogadro's number.
T: What is Avogadro's number?
Ss: 6.02×10^{23} molecules (in chorus).
T: How much is the mass of one molecule? What is the thing that contains Avogadro's number of molecules? (The second question was repeated.) Yes? (She picked one student.)
S: Molecular mass in grams.
T: Molecular mass in grams. Mass of a mole is equal to the molar mass in grams. Where can I obtain the molar mass from? From the molecular formula (answering herself directly). What is molecular formula for sugar? You took this in biology. Yes (pointing to a student).
S: $C_6H_{12}0_6$.
T & Ss: $C_6H_{12}0_6$ (in chorus) (from Lesson 2-3).

Questions to be answered individually are usually presented for the first time in the corresponding lesson. The answers usually need more than yes or no; they require more than one word. They may involve a memory search for previous learned definitions, a recognition of differences or reasoning why. In such questions, the teacher usually faces the class searching for someone to call on. While she is stating the question, few hands are raised. Students with hands up whisper, "me, miss; me, miss." It is probable that the student who is called on to answer cannot answer correctly; then the teacher's response to this incorrect answer will differ depending on the teacher's perspective about that particular student, as seen later when categories of students are addressed.

There are cases where Miss Talib was bothered by the choral response of the class and gave directions not to answer in group.

Analyzing the three typical lessons with a special interest in the questioning skills of Miss Talib reveals the following:

Questions to "called on student by name":	41	124 (41 + 83)
Questions to "called on student without name":	83	
Questions "answered by choral response":	159	
Total number of questions:	283	

The total time spent in asking them questions of the first two types during the three lessons was 13.95 minutes, and the total time for answering these questions was 9.45 minutes. Usually a question took more time in stating because is was a complete, meaningful statement, repeated or paraphrased twice in most cases (sometimes more than twice). Each question on the average had 6.75 seconds to be stated by the teacher and 4.57 seconds to be answered.

Table 4.9
Calculation of the Average Time for Asking or Answering a Question in Typical Lessons

		No. Tallies	
	Lesson	T. asks (Cat. 4)	S. ans. (Cat. 8)
	1-4	126	95
	2-3	75	45
	3-2	78	49
Total No. of Tallies:		279	189
Total Time in Seconds:		837	567
Total Time in Minutes		13.95	9.45
Total Number of Questions:		124	124
Average Time for Each Question:		6.75	4.57

The time used for asking questions of the third type was not recorded separately because, according to Flanders' system, these are not considered to be questions. Miss Talib also considered this type of solicited response as a teaching strategy, not as questions, per se.

By examining FIAC matrix of typical lesson 2-3 (see Table 4.8), it is interesting to realize the absence of pause periods from the type 4-10-8 which indicates a wait time of three seconds between the teacher's question and the student's answer. There is only one instance where a pause of three seconds followed a question. This instance came in a sequence 4-10-10-7-7-8. The question in this case was not stated clearly, and the student who was called on to respond could not respond (first pause); other students hesitated to raise their hands (a second pause mixed with whispers); then the teacher criticized the class using four threatening questions in six seconds. Few students raised their hands, and the teacher called on one of them to respond.

Most of the 4.94% of the lesson's time in category 10 represents the types 3-10-5 and 5-10-5 which have pauses during the teacher talk, especially when she is writing or drawing something on the board.

During an increasingly rapid rate of teacher's lectures, comments, and questions, students have very little time to think. Wait time after questions is in the range of 1-2 seconds. If the student is not able to think quickly enough to respond, the teacher repeats the question, paraphrases it, ask a different question, or calls on another student.

Student Categories

After two or three lessons of observation, the observer in Miss Talib's classroom becomes familiar with names of certain students in the class. Few students' names are called on very often; other names have never been called on during the whole period of observation.

Rana, Hamama, Jamila, Nadia, and Manal whose names are called on most often are among the best students in terms of achievement on tests. They are also the only students who initiate questions or comments in the classroom. They represent a group of students who "understand well from instructors," raise their hands if questions are offered, and answer correctly if called on. If a student from this group does not understand something or questions the teacher's ideas, the teacher will take this as a sign that the situation needs more clarification. In two cases of this type, the teacher called on the observer to make the clarification. The teacher gives more time to a student in this "steering group" to respond or to correct herself if she does not answer correctly on the first try.

Among the more frequently uttered names are a few students who represent another group, those who sit quietly, listen passively, do not ask questions, and very seldom answer a question correctly. If a student in this group answers correctly, the teacher makes sure that the student is not reading the answer from her notebook. The teacher then asks another question to determine that the student's answering the first question correctly was really a sign of understanding. Whenever a student in this group answers incorrectly, she will not be given time to correct herself.

A dramatic example of such a difference in treatment of the two types of students is shown in the following extracts.

<u>Example 1</u>

T: Some alpha particles pass through the (gold) sheet (in Rutherford's experiment) with deviation in their paths, and some particles are reflected. Why, Banan?

B: (Reading from her notebook) The deviation of some particles from their paths and the reflection of some others indicates that the atom has a very small area in which the matter of the atom is concentrated . . .

T: You have copied this answer from the textbook. Explain it to us; leave this notebook aside. (The teacher took Banan's notebook, looked at the answers, and said, "Is this a notebook?") What is the small thing?

B: Very small region with positive charge.

T: What is the positive charge? Who has the positive charge in the atom? What does the atom have?
(The teacher threw the notebook on Banan's desk.)
We are back to the stupidity of the beginning of the year. Do you want me to spank you twice and cause a dizziness for you? Do you want us to waste the time on the stupid people of the class?
(The teacher turned to the class with anger.)
Small number of particles are reflected; others deviated. Why? (Lesson 3-6.)

Example 2

T: We come back to the ionic bond. What is the ionic bond? What is the ionic bond, Nuha?

N: It is the bond whose molecules conduct the electrical current.
(The teacher was standing near Nuha, facing her directly and giving her gestures of rejection to her answer.)

N: (Trying to give a better statement) The bond whose atoms or molecules . . .

T: Do we call them atoms and molecules? Does an atom have a charge?

N: The atom has in it a nucleus . . .
(Noises from other students.)

T: Oh, class, let us understand from Nuha. What is the atom?

N: It is the smallest part of the matter.

T: What are its components?

N: Protons, neutrons, and electrons.

T: What is the charge of the protons.

N: Protons are positive, neutrons are neutral, and electrons are negative.

T: What about the electrons and protons?

N: They are equal in number.

T: Positive charges are equal to negative charges. How is the atom?

N: Neutral.

T: How do atoms and molecules of ionic bond conduct electrical current? Are not the atoms neutral? How do they conduct the current? Who conducts the current? What should be available in order that the current be conducted? Why did not you study, Nuha? Sit down and listen (angrily) (from Lesson 3-6).

Compare these two cases of Banan and Nuha with the following two extracts.

<u>Example 3</u>

T: (Reading question number 14) Explain why a glass rod is charged positively when rubbed with silk, Manal.
M: Because the glass has a negative charge. Electrons from it go to the silk.
Ss: No, miss.
T: No, the glass is positive and the silk is negative?
Ss: Me, miss; me, miss.
T: No, let Manal herself answer.
M: Electrons move from silk to glass.
T: It (the glass) is positive; if it takes electrons, then it will be negative. Which one loses electrons?
Ss: Silk.
M: Silk.
Ss: No, no . . .
T: Let us go with Manal as she likes. Silk loses electrons and it becomes positive. But what does the question say? The glass is positive and the silk is . . .
T & Ss: Negative
M: The glass loses electrons and becomes positive. The protons become more than electrons, so the glass becomes positive. Silk takes electrons, the electrons become more than protons, and the silk becomes negative.
T: Of course, the transfer of electrons is caused by rubbing (the glass with silk). Question 15 . . . (from Lesson 3-6).

<u>Example 4</u>

T: CH_4 carbon (drawing the nucleus and electrons in orbits) has atomic number six. The atomic number is . . .
T & Ss: Six 2 and 4.
T: How many (electrons) in the outside orbit?
T & Ss: Four.
T: Does it (carbon) tend to gain or lose (electrons? Jamila?
J: Tends to gain.
Ss: Does not gain or lose.
T: Now generally speaking, it has four (electrons); does it tend to gain or lose?
J: Sometimes it loses; sometimes it gains.
Ss: (noises)
T: Does it gain or lose?
J: It tends to lose.
T: Does it lose the four (electrons)?
J: (silence)
S: Share
S: Does not lose and does not gain.
T: Does not lose nor

T & Ss: Does it gain

T: It likes to share. (Then she moved on to show how C atom shares with four H to form CH_4.) (lesson 3-6)

Jamila and Manal belong to the steering group. Two similar cases, with Hamama and Nadia, form the same group are also distinguished. Banan and Nuha belong to the group whose names are also frequently heard in the classroom. Four more names can be easily distinguished as belonging to this group. Members of this group seem to get some attention from the teacher. They are frequently called on to answer questions and to check their notebooks and their attentiveness. They get considerable verbal punishment (and physical punishment, in one case of four students). The teacher feels that these students should be reprimanded for their laziness and carelessness.

> Some students are careless. They do not mind whether they understand or do not, and they do not even ask questions about what they do not know. I am concerned about them because if neglected a student of this type will never improve. One student started to study well after I reprimanded her in front of the class. Sometimes I call on a student of this type to go to the board and answer a question or solve a problem, and I know that she cannot; but I need to put pressure on her and to notice where the weakness exists . . . (from an interview with the teacher, March 11).

This group will be called the "concern group." Three students of this group (the teacher calls it Group C) have been interviewed and expressed their frustration for this kind of treatment. All the students who were interviewed mentioned that they do not ask questions if they do not know something, because they are afraid of hearing insulting comments from the teacher. One student expressed her feeling this way:

> I prefer to ask another girl after the lesson. I am afraid to hear some words. She (the teacher) will start saying, "Did not we explain this?"; then she will add a few words of insult. Miss Talib is a good teacher; she is not a special case in this; all teachers do the same ..."

Another student who is the sister of Miss Talib and belongs to the "steering group" was asked by the researcher why most students do not ask questions about what they do not know. She answered in this way:

> It depends on the nature of the student herself. Some students are courageous, most of them are afraid. A student is afraid to ask questions, afraid of the teacher, afraid for the other students to get the impression that she does not understand, and even afraid of herself . . .

Miss Talib is aware of these two groups and of a third one which makes up the majority, the average type students, who are considered a "reference group" (or group B) by Miss Talib.

> You have to explain the material at the level of the average student. Those who are above the average should accommodate themselves to this method; those who are below should improve themselves in order to catch up. It is a frequent practice to ask another student or merely to repeat the correct answer already given, because this is useful for students of the type C. Repetition teaches the donkey, as the proverb says. But I can't do this always in order that all students will understand; where is the time for this? What will happen to the required material that I have to cover and the plan that I need to finish? One cannot guarantee that all students of the class have understood the subject 100%. There are always five students in every class who are careless, and they know themselves. They know that they will repeat the general exam . . . (Interview, March 1).

It was noticed earlier in the analysis of classroom verbal interaction that categories 1 and 2 are almost empty. The very few words of thanks are mostly offered whenever a student performs a procedural duty--cleaning the board, bringing something from the office, and the like. Only one instance of acknowledging a student's idea was recorded during the period of observation. The teacher was talking about solar energy as a method of purification of sea water when a student volunteered to mention that Jordan has a station for using solar energy in Agaba. The teacher made a few comments about the station and thanked the student for bringing this into the discussion. Only one instance was recorded where the teacher made a joke about one student who was making jokes about the science course (how difficult it is and how science teachers turn students crazy) during the previous day, the day of school activities. It seems that this was reported to Miss Talib, so she started the lesson of that day by referring to the student's jokes which made all the class laugh. Then she added a few words of criticism of the student. Other than that, each lesson was a continuous flow of verbal communication about official business, the kind of classroom that Flanders (1970) calls an "afflectional desert."

The Teacher's Power and Control

A major criterion for the science supervisor's choosing Miss Talib to participate in this study was her confidence in herself and her strong personality. Statistics of the Ministry of Education in 1980 show that 92% of the total number of teachers at the secondary level are not qualified to teach according to the official qualifications required by Education Act No. 16 of 1964* (Jaradat & Abdul-Hamid, 1980). Miss Talib is considered among the eight percent of teachers in Jordan who are certified to teach at the secondary level since she has a diploma in education (33 credits hours of graduate work) beyond her Bachelor's degree in chemistry. This fact might contribute to part of her confidence, but the patterns of communication and roles played in the classroom will help in better understanding the position of the teacher. Two major roles for Miss Talib in her classroom can be identified, both of which have the spirit of control--control of knowledge and control of the social order.

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*To be certified to teach at the secondary school level, a teacher should have at least one year of graduate studies in education, in addition to the bachelor's degree in a subject matter area.

Control of Knowledge ←-------→ Control of Social Order

Both roles are carried out simultaneously, and to maintain one role, the other should also be maintained. The teacher feels that she has to be in control of the educational process, on one hand:

> If I do not guarantee this control, can you imagine what a class of 56 students of this age would look like in terms of noise and disturbance? How can any kind of learning be achieved without such control? What would the school principal or visitor from the office of education think of a teacher whose classroom is not well disciplined and controlled? (Informal discussion with Miss Talib, Fieldnotes, February 16.)

On the other hand, the teacher is expected to teach the textbook, so the sequence of topics and the organization of the subject matter should meet the semester plan to cover all topics:

> I need the least amount of interruption to carry out my plan. I cannot proceed on the pace of those slow learners. I have no time to wait for them. They have to raise their level to the average. I do not teach 20 or 30 students in a classroom. I teach 50 to 60 students (Informal discussion with Miss Talib, Fieldnotes, February 16).

So there are many academic and social constraints under which the teacher works and which legitimize and justify the authority the teacher has to have to perform her duties. Expectation of the administrative staff, pressure of the curriculum, the large number of students in the classroom, and the attempt to avoid the risk of problems can be identified among those constraints.

Authority of a teacher should be distinguished from the power she might possess. Authority of a teacher implies a certain set of roles recognized clearly by students where the teacher also feels legitimate in exercising her control in the classroom. Power, on the other hand, refers to the spirit of dominance which is possessed by a powerful teacher whether students like it or not.

The relationship between Miss Talib and her students involves consistent forms of interaction related to the organization and pace of the knowledge transmitted and received where the teacher exercises her authority with no need or chance for negotiation. But even in other areas such as classroom management and discipline where students might have considerable power or right (a more appropriate term) to negotiate a working consensus at the individual or collective level, Miss Talib seems to display her power in forms of commands backed by threats or questions worded in reprimands to justify the required behavior (see the extract from lesson 2-3 in Appendix E).

The picture of classroom interaction should be seen in the immediate flow of teacher-student interaction (at the micro-level) without denying the impact of some subtle ways in which broader social structural factors exist at the macro-level. But this does not necessarily need to carry out a systematic analysis from one level of the social hierarchy to another. The position adopted here is that teachers and students can accomplish teaching and learning together in certain social interactions and under conditions which are of their own choice. There is no need to explain the teaching-learning behaviors in a deterministic manner referring to external forces. The performance of administration, the communication channels with those on "top," the societal view of the teacher, parents' neglect of their children, low salaries in the teaching profession are always issues of discussion in the teachers' hall. Such external forces are always referred to and viewed as causes of all ills in education. Since teachers feel their inability to deal with such causes, the result of such discussions is, in one word, frustration. Edwards and Furlong (1978) refer to social structures as the product of social interaction of the human agency and at the same time the medium through which interaction in that form is possible.

Evaluation of the Teaching-Learning Process

This section is intended to look at the evaluation process as one phase of the teaching act in Miss Talib's classroom. At the beginning of second semester this year, the Northeastern secondary school received from the Office of Education a new model of a planning book where the lesson plan lists the components vertically as shown in Appendix L. The introduction of the planning book emphasizes, however, that:

> The teacher should keep into consideration that evaluation is a continuous interrelated and integrative process which measures the extent of achieving the lesson objectives in light of the general goals of the subject, in order to help the student modify his/her behavior towards the better.

Rhetorical questions were used quite often by Miss Talib to make sure that the class as a group could repeat the correct information after it had been stated. But she also asked questions to individual students or asked the class to solve a numerical problem in their notebooks as part of the continuous evaluation. The frequency of such questions was low and in some lessons evaluation can hardly be seen. The level of the teacher's awareness of continuous evaluation did not satisfy four professors of education at Yarmouk University who independently viewed the videotape of lesson 2-5. Three of them observed that she seems not aware of the continuous evaluation while the fourth observed that, "I did not feel the presence of any activity or even indication of evaluation in which the teacher tried to make sure whether the girls have learned something or not" (Viewing session and interview with Dr. Hasim, March 13).

A science supervisor in a neighboring district viewed the same tape and noticed that:

> Questions which the teacher uses can be categorized in one type, they are direct questions, on the surface, related directly to an already mentioned bit of information. She does not use the deep probing question in which she can find out the problematic aspects in the students' learning to deal with them" (Interview after a viewing session with Ali Hatim, a science supervisor, March 14).

Whenever the teacher asks a student to solve a numerical problem on the board, the student had very little chance to present her own understanding of the problem. The continuous flow of questions and comments of the teacher guided the student to perform exactly what the teacher wants her to perform. An example of this is shown in appendix . . . (lesson 2-3) where Rana was expected to work out a problem on the board about the procedures of preparing a solution of NaCl which has a molarity of two moles/litre. All Rana did while at the board was write what the teacher dictated. There were only two instances where Rana uttered something.

One way to check the student's understanding is to check the quality of the work in the notebooks. Miss Talib did, in fact, do this checking, but her interest was whether a student tried to do the homework. She asked, "Who of you did not try to answer the questions?" If she chose to examine the notebooks of some students, she would offer some comments about the organization of the notebooks in addition to the content of the homework.

One of the instances in which the teacher got valuable knowledge of students' learning was the follow-up of seat work which happened only in solving numerical problems. In such a case the teacher had the chance to see the strategies of solving problems in the notebooks of the first few students who finished their work quickly. When the number of students who finish the work and leave their seats to show the teacher their work increased considerably, the time allowed to do seat work was terminated, and one student was called on to work out the problem on the board.

The official evaluation record divides the total score of the semester into certain components. The teacher was expected to make tests and to record scores according to the agenda presented in Figure 4.4.

The teacher was expected to make at least six exams, to grade them, record their scores, and to return the graded papers to the students. In many cases the teacher makes more exams than the required number, then chooses some of them to be included in the evaluation record. Twenty percent of the total score is devoted to making an assessment of the students' activities during the semester. Such activities usually include lab performance, if any; individual projects and reports about extracurricular activities; classroom participation; lab notebook and/or classroom notebook; etc. Miss Talib has to fill in a record of this type for each of the seven classrooms she teaches. It is really a heavy load, especially when this is added to the other administrative responsibilities that every teacher has to share.

During the period of observation, Miss Talib made several tests, but three written tests made for the purpose of this study were also used as part of the classroom test record.

The exam is not considered a welcome event for the students or for the teacher. For a teacher to prepare the test, grade it, and record the grades in a classroom of 50 to 60 students is a burden. For most students, the exam is an occasion for anxiety with very little impact on their learning and understanding. The exam traditionally is a measure of how much a student does know. The exam is often used as an instrument of threats and punishment. Miss Talib tried to relate the concept of concentration in lesson 2-3 to the number of molecules defined in the mole according to Avogadro's hypothesis presented in the first chapter. She called on Majida to define Avogadro's hypothesis. Majida did not respond, other students started whispering, but no hands were raised. Miss Talib addressed the class, saying, "What is the problem, class? Would you like me to give you an exam? Or what? Return to the custom of expelling out of the classroom?"

In grading a paper, the teacher marks the responses right or wrong. The incorrect responses are very seldom brought into the discussion, and the individual student does not have enough courage to ask the teacher why they are

Student Names	A	B	C	D	E	F	G	H	I	J	K	L	K + L
1													
2													
3													
4													
5													
6													
7													
8													
etc.													

Key:

A: Score, first month
B: Score, second month
C: Average of A and B
D: Two month exam score
E: Score, third month
F: Score, fourth month
G: Average of E and F
H: Average of C, D, and G
I: Semester final
J: Semester exam score (average of H and I)
K: 80% of J
L: 20% for activities
K + L: Semester score

Figure 4.4. Agenda of school examination for one semester.

wrong. The tests made for the purpose of this study in Miss Talib's classroom have valuable information about students' learning. Miss Talib did not make use of any of them. The only thing she was interested in was the list of names with total scores on each test.

Student Learning Outcomes

Introduction

It is useful at this point to distinguish between the intended learning outcomes and the accomplished ones. Earlier in this chapter, the general goals of the natural science course as defined by the textbook and the teachers' guide were briefly mentioned. The teachers' guide specified the objectives of each chapter of the textbook. If the teaching-lerning process of the first three chapters of the NSC at the tenth grade level were successful, then the students would be able to achieve the objectives listed in Table 4.1.

It is clear from Table 4.1 that the objectives intended by the curriculum writers included conceptual knowledge learning, affective learning, and skill learning. If these three facets of science have appropriate shares in teaching and learning science, then it is hoped that the nature of science as an integral body of content, process, and attitudes can be understood.

The teacher is expected to write down in his/her lesson plan the general goal and objectives of teaching each lesson. Appendix L shows that the statement of general goals written by Miss Talib has three parts:

1. acquiring certain knowledge about nature and about science (cognitive learning),
2. developing scientific attitudes (affective learning), and
3. developing intellectual and sensory skills (skill learning).

Developing Attitudes Toward Science

Miss Talib seems to be concerned about developing positive attitudes toward science in her students. She was upset when she learned that one student was singing a song about the difficulty of understanding science and how science turns students crazy. She employed the textbook's suggestion of asking students to find out about methods of salt water purification from other resources, books, or persons and to write reports about the subject. This activity was part of the 20% semester score devoted to students' activities.

But the ways in which Miss Talib has referred to students' abilities to learn science were seen by some students as an indication that science is a difficult subject and some students were not able to study it. In her response to a student who did not answer a question correctly (Lesson 1-6), Miss Talib made a statement which has some relevance.

T: These proportions are applications of which law, Banan?
S: (Silence.)
T: What is this, Banan? For how long should we wait for you? Are you going to be in the science branch?

On a similar occasion, she addressed another student, saying, "What is the problem with you, Sabah? From the beginning of the year until now, you did not improve. Can't you understand science? Or is science beyond your ability?" (Lesson 2-9).

Both Banan and Sabah viewed such statements of Miss Talib as indicators that science is a difficult subject and they would choose the literature branch because it is easier than the science branch. Banan expressed the influence of the teacher's statement on her perception of science more explicitly, saying, "Did not you hear her (Miss Talib) saying not any student can be in the science branch? Science branch needs people who can understand science and do well in it!" (Interviews of students, "Banan," March 11).

Developing Scientific Skills

The authors of the teachers' guide expected that learning some scientific skills would be directly related to doing practical activities. If students do not have the chance to do such activities, to be involved in solving problems, and to finding out about things, using their senses and pieces of equipment to employ certain procedures, the skill and process aspect of learning science is not expected to develop. The practical activities conducted by Miss Talib were mentioned earlier. Students in Miss Talib's classroom did not have the chance to practice any practical activity.

The intended outcomes referred to by Miss Talib's lesson plans did include the three aspects of learning science: content, process, and attitude. But the major emphasis in her classroom teaching was on learning the cognitive content of the course.

Students' Conceptual Learning

The following section will address the students' learning outcomes related the content of the course using three different sources of data, the students' responses in the classroom, during the interviews, and on the following written tests prepared by the researcher:

--25 multiple choice items, pretest (1.1) and posttest (1.2) of chapter one

--30 multiple choice items, posttest of chapter two (test 2.2)

--3 free response items at the end of chapter two

--22 multiple choice items, pretest of chapter three (test 3.1)

--33 multiple choice items, posttest of chapter three (test 3.2)

--1 free response item at the end of chapter three

Similar items in the pre- and posttest will help to investigate the change in students' perceptions of some concepts as a result of learning. A number of items from chapters one and two were also repeated in the posttest of chapter three. This helped to investigate the retention factor in student learning. It is not the intention of this section, however, to deal with all aspects of these responses because this will make the discussion a voluminous one. The goals and objectives of the course as presented in the teachers' guide were used as indicators of the importance of some aspects which were chosen to focus on. Miss Talib used the responses on the three posttests as evaluation measures to be included in her evaluation records of the classroom. The quantity of learning is the focus of evaluation in this case (see Table 4.10).

Table 4.11 shows the students' lerning outcomes as measured by the three multiple choice posttests combined together. The total number of items in those three tests is 88. It is obvious that no student was able to answer all the items correctly. Very few students (9.4%) answered 75% or more of the items correctly, 69.2% of the students answered 50% of the items correctly and were considered successful, while the rest (30.2%) wee considered failures. All students answered 31% or more of the items correctly. The mean score for the whole class was 57% (Table 4.10). Figure 4.5 shows that the distribution of the scores was not too far from the normal. When the three posttests were viewed separately, as in Table 4.12, the highest performance for the students was shown on test 3.2 at the end of Chapter Three, while the lowest performance was shown on test 2.2 at the end of Chapter Two of the textbook.

Such statistics--the mean, the percentage of success, etc.--are often used by school teachers to describe students' performance on their courses and to compare classrooms with each other as well as to make decisions about students who should be in the scientific branch, who should take the exam for the course again, and course again, and who should be promoted to the next grade. Although such statistics have some indication about the quantity of student learning and provide some base for comparing students and making decisions,

Table 4.10

RESULTS OF THE STUDENTS' PERFORMANCE ON THE THREE POSTTESTS

Name	Raw Score of 1-2 (Max. Score 25) a	Raw Score of 2-2 (Max. Score 30) b	Raw Score of 3-2 (Max. Score 33) c	Total a+b+c d	% of $d = \frac{d}{88} \times 100$
AFIFI, M.	10	17	12	39	44
AMAL, A.	17	12	19	48	55
AMAL, H.	12	13	20	45	51
AMAL, S.	16	16	14	46	52
AMINA, A.	16	15	24	55	63
AULA, G.	17	13	20	50	57
AULA, K	16	13	16	45	51
AURAIB, A.	14	14	15	43	49
BANAN, J.	10	14	17	41	47
BANAN, T	11	17	13	41	47
BASHIRA, M.	8	11	22	41	47
BASMA, F	19	6	23	47	53
BUTHAIN, A.	18	20	24	62	70
FATIN, S.	15	12	18	45	51
FIRIAL, A.	12	7	15	34	39
GAMAR,A.	12	15	20	47	53
GAZALA, A.	12	15	18	52	59
GAZALA, S.	19	13	26	51	58
HAMAMA, A.	18	20	19	57	65
HANIDA, M.	22	21	25	68	77
HANAN, J.	17	20	30	67	76
HIDAIA, S.	11	12	17	40	45
JAMILA, M.	24	25	30	79	90
KHITAM, M.	11	17	12	40	45
KHITAM, S.	22	14	29	65	74
LINA, A.	15	9	17	41	47
LUBNA, G.	13	12	22	47	53
MAIS, A.	15	21	23	59	67
MAJIDA, D.	11	18	10	39	44
MALAK, E.	13	10	16	39	44
MANAL, A.	15	19	19	53	60
MANAL, M.	14	17	20	51	58
MARY, M.	23	23	22	52	70
MATAF, M.	18	16	22	56	64
MUNA, D.	17	18	19	54	61
MUNA, M.	13	14	14	41	47

Table 4.10, continued

NADIA, T.	21	23	29	73	83
NAWAL, F.	16	23	16	55	63
NIDA, E.	18	20	24	62	70
NUHA, H.	18	19	21	58	60
NUHA, M.	16	18	22	56	64
RAHMA, M.	9	13	12	34	39
RANA, S.	21	25	28	74	84
RUBA, A.	13	11	22	46	52
SABAH, M.	13	8	11	32	36
SAFA, E.	13	11	18	42	48
SAJIDA, A.	17	15	20	52	59
SAJIDA, M.	15	14	24	53	60
SAWSAN, A.	17	17	20	54	61
TAQWA, R.	17	17	29	62	70
WISAL, M.	5	12	10	27	31
ZAIN, A.	16	14	16	46	52
ZAINAB, A.	15	12	17	44	50
Mean:	15.09	15.49	19.58	50.18	50.02

Table 4.11
Students' Responses on the Three Multiple Choice Posttests Combined Together

Percentage of Items Answered Correctly	Percentage of Students
100	0.0
75	9.4
66	22.6
50	69.8
31	100.0

Table 4.12
Students' Responses on the Five Multiple Choice Pre- and Posttests

Percentage of Items Answered Correctly	Percentage of Students on Each Test				
	1.1	1.2	2.2	3.1	3.2
100	0.0	0.0	0.0	0.0	0.0
75	0.0	13.2	9.4	0.0	22.6
66	0.0	35.8	20.8	0.0	37.7
50	13.2	71.7	52.8	11.3	77.4
25	88.7	98.1	96.2	83.0	100.0

Table 4.13
Frequencies

Score Intervals		Midpoints of Intervals
90	1	92.5
85	0	87.5
80	2	82.5
75	2	77.5
70	5	72.5
65	2	67.5
60	8	62.5
55	6	57.5
50	11	52.5
45	9	47.5
40	3	42.5
35	3	37.5
30	1	32.5
25		90-94

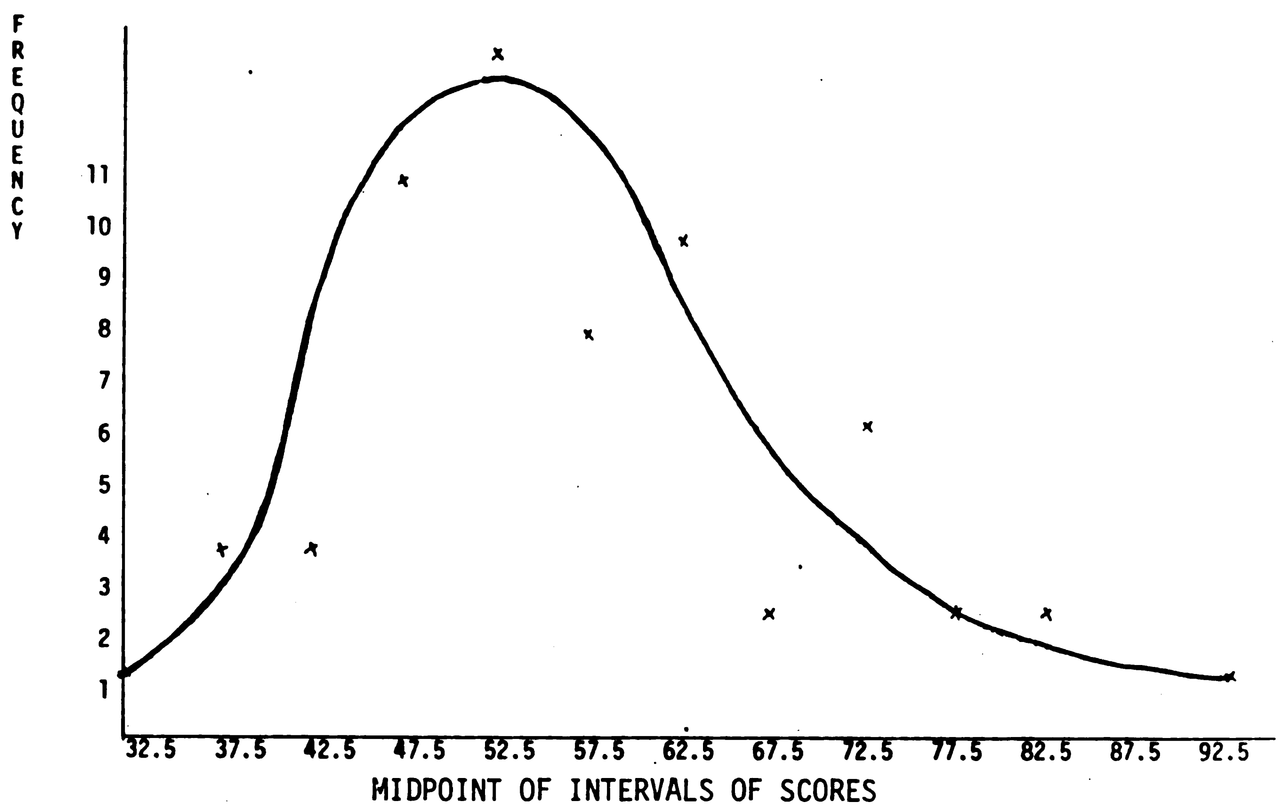


Figure 4.4. Graph of frequencies of students' scores on three posttests

they do not provide much knowledge about the quality of student learning. There are some intended learning outcomes which might not be accomplished by the majority of the students. In this case, a closer attention should be paid to such learning outcomes, their suitability for inclusion in the course, the method of presentation in the textbook, and the method by which they have been taught in the classroom.

Appendix F shows the frequencies of students' responses on the four alternatives of each item in the all-multiple choice tests. The following sections have presented some aspects of students' learning as shown through the performance of students on those tests, through their responses in the classroom and through their responses to the researcher's questions in the interviews.

Learning about the Nature of Science

Understanding the nature of science and the work of scientists was considered a major goal for the whole course. Volume one which was taught in the first semester of the year dealt with this in the unit devoted to experimentation, measurement, explanation, and prediction. In the second volume, unit three starts by referring to the fact that experiments that scientists have done on the structure of matter can be done by anyone, and the results of scientists' work are not absolutely true--they have a temporal nature and are subject to change. The pretest of chapter one has these two items:

Item one: Experiments that were conducted by scientists during their investigations in the nature of matter are characterized by:
1. no one except scientists can repeat them,
2. anyone can repeat them,
3. they did not provide evidences on atoms and molecules, or
4. they proved that the molecule is the smallest part of matter.

Item two: When scientists come to some conclusions depending on practical experiments, their conclusions are:

1. correct in all circumstances,
2. temporal subject to change,
3. not possible to accept them until other scientists come to similar conclusions, or
4. incorrect if the prevailing theories cannot explain them.

The distribution of student responses is shown in Table 4.14

Table 4.14
Responses of Students on Item One and Item Two

	Item One			Item Two		
Choices	Pret.1	Postt.1	Postt.3	Pret.1	Postt.1	Post.3
1.	11	15	5	2	1	7
2.*	6	14	39	* 16	25	33
3.	5	5	2	32	15	8
4.	29	19	7	3	12	5

* 2 is the correct response in both items.

It is clear that the number of students who responded correctly have increased through the time of teaching the unit and more students are learning. But after the teacher covered chapter three, the students' views of science and scientists' work were becoming closer to what was intended. It was interesting, however, that until the end of teaching chapter three, which has much of the description of scientists' work and possibility of doing their experiments, there were students who stuck to their misconceptions. Two students were identified who continued to hold the idea that experiments of scientists did not provide evidence on the existence of atoms and molecules. These students were asked about their reasons for this misconception. Their responses were basically similar and interesting. One of them said:

> Atoms or molecules were not found to be in existence in the real sense. There is no way to prove that by experiments. Scientists invented these names to understand the structure of matter. They are theories, atomic theory or molecular theory. Scientists accepted these theories because there are no better theories. In the future scientists may come up with better theories because the new theories may explain more observation, but they will continue to be theories.

This student was considered a smart girl in the classroom, although her performance on tests was not comparable to the clarity of her judgment. She answered the second item correctly, holding the idea that scientific conclusions are temporal and subject to change. When she was told that the right answer of item one was the fact that any person could repeat the experiments that scientists have done before, she replied, "I thought that this idea was definitely incorrect, because it is unreasonable to think that anyone can do that. More reasonable is to say any other scientist or anyone who is qualified or trained."

Item 21 in the pretest and posttest of chapter three is related in its meaning to item two above.

> Item 21. Dalton suggested the atomic theory to interpret a number of phenomena and experimental laws which were known at his time, but later his theory failed to interpret other phenomena and observations. This means that:
>
> 1. there is a need to develop new experiments in order that their results conform with the theory.
>
> 2. there is a need to modify Dalton's theory to be able to explain the new experiments.
>
> 3. the previous laws and experiments did not have correct results.
>
> 4. the explanation of Dalton's theory of the previous observations and experiments was incorrect.

Student responses on the different alternatives of the items are seen in Table 4.15.

Table 4.15
Students' Responses on Item 21, Test 3.1, 3.2

Choices	Pretest	Posttest
1.	12	13
2. *	29	24
3.	8	7
4.	2	5
not answered	2	4

*the correct answer

Dalton's model of the atom is an example of the fate of the theory that fails to explain new observations and new results. The number of students who realized that Dalton's theory has to be modified (29) was reduced in the posttest to 24 students. The number of students who thought that experiments should be developed to get results which are in conformity with theory and those who thought that explanations of previous experiments according to Dalton's theory were incorrect changed very little. Four students in the posttest left the question unanswered. On item two, four students of those who thought that in the case of the failure of the theory to account for some experimental conclusion, the conclusions are considered incorrect were consistent in that belief. In item 21, they based the need to develop the experiments so they gave results which conform with the theory. It seems that such consistency in their perception prevented them from following the major theme of the unit which is the continued development, change, modification of new theories to respond to new discoveries and observations. This might also provide the conviction that students' previous knowledge will be of great help or hindrance to learning new knowledge on the part of many students.

Item 20 in test three required students to distinguish between a statement of explanation and a statement of description. Before starting chapter three, students held certain ideas about the distinction between description and explanation as two basic activities of science. Laws and theories were redefined in chapter one to employ this distinction. But the study of chapter three added more confusion to what students had before. Only eight students from the 18 who identified the descriptive statement preserved their conception. The attention of many students (28) was directed to chose the explanatory statement to be a descriptive statement. In fact, this statement was given in the textbook as an explanation of an observation (p. 76). Both the descriptive and explanatory statements were illustrated in figures in the textbook. In this respect, most students (34 of 53) were able to realize the fact that the laws of science are descriptive statements or relationships. But the problem might be in the analysis of the statement to find out whether it carries a relationship between two or more factors (description or law) or implies an attempt of understanding the meaning of a theory.

Learning Laws of Chemical Composition

Patterns in Miss Talib's use of questions were reported earlier in this chapter. Most questions were found to be of the rhetorical type where the statement of the question carries a clue to the required response, and responses are given by students spontaneously in a choral manner. This practice can tell very little about students' learning. Questions directed to individual students might tell something. Students of the steering group and of the interest group received considerable numbers of such questions. The responses usually depended on the level of the questions. In most cases students of the steering group were able to answer any questions correctly, but there were instances in which the observer easily realized that even students in the steering group had not learned much. Laws of chemical composition is an example. Miss Talib spent one lesson in presenting these laws using examples from the textbook. In the next lesson, she spent 14 minutes reviewing these laws. During the review, students showed very little participation. No student was able to define any chemical law on the first try. Manal, a student from the steering group, was called on to give an example of the law of definite proportion. She did not give an example in her response; she only calculated the proportion between the mass of oxygen and hydrogen in water without relating it to anything else. She was able to state a few facts which are necessary to come to a conclusion about the law, but she did not reach that conclusion. The teacher made the necessary illustration by explaining two methods of preparing water and indicated that in both cases a water molecule has the same proportion of oxygen and hydrogen. When she asked students to state the law and repeated the question twice, none of them raised their hands. The teacher paraphrased the definition and asked the question again, and this time six students raised their hands. Hamama was called on to respond, and she gave a satisfactory statement. No student raised her hand to define the laws of simple multiple proportion. The teacher asked the students to give an example of the law, and Rana was the only student who raised her hand, so the teacher got upset and reprimanded and threatened the class: "You either study well or leave the classroom." When Rana was called on to respond, the situation was similar to the earlier case of Manal and the second law: Rana calculated the proportion of carbon to oxygen in carbon monoxide (3:4) and in carbon dioxide (3:8), but she did not make the required conclusion. Miss Talib called on the best student, Jamila, to state the conclusion. Jamila's statement was a meaningless one, so the teacher tried to correct it by using another incorrect statement, repeating the incorrect conclusion while the class was repeating with her in chorus.

T: Any two elements always react with each other to produce more than one compound. The proportions are:
(The following statements can be distinguished in the chorus.)
T & Ss: Multiple of each other.
Ss: Simple numerical proportion (the correct phrase).
Ss: Constant proportion (from Lesson 1-4).

The inability of most students to show an active role in this lesson was realized by the teacher, and on two occasions she reprimanded the class for that (see fieldnotes of lesson 1-4 in Appendix C).

Several errors were made by the teacher and by some students without being corrected, besides the several statements made by the teacher which were not accurate. During the time which was given to students to copy the "correct solution" from the board into their notebooks, Miss Talib examined the notebooks of a few students and found that one student had solved problem 12 at the end of chapter one (lesson 1-6) in a way which was different than Miss Talib had. The student's solution was, in fact, correct, and showed that she had a good grasp of the problem. However, Miss Talib showed that the student's method was incorrect. In the same lesson one student was solving a problem on the law of multiple proportion on the board. She calculated the mass of an element which combined with one gram of oxygen in the first compound and the mass of oxygen which combined with one gram of the element in the second compound. The result, of course, was not correct, and the teacher did not make the needed correction.

Forty-three students were not able to recognize the definition of the law of multiple proportion before Miss Talib taught chapter one in the textbook. Thirty-four of them were not able to do so even after they were taught the chapter. Large numbers of students (21) confused this law with the law of definite proportions (item 17, test 1.1 and test 1.2). The problem which the teacher faced in teaching this topic can account for the fact that students did not seem to learn much and the teacher was frustrated by their level of participation in the classroom. Although Miss Talib blamed the students for this, both the students, on one hand, and the teacher, on the other hand, seem to be the victims of inadequate presentation in the textbook which put more emphasis on stating the definition and solving numerical problems which were poorly constructed than on building an adequate understanding of the concept.

Kinds and Numbers of Atoms in a Molecule

Eleven students were interviewed individually, each for a few minutes. Three main questions were asked. The first question was about the difference between the number of atoms and kinds of atoms in a molecule, the second question was about the direction of an electrical current, and the third question was aobut the relationship between the boiling point of a pure liquid and a solution. Identifying the different kinds of atoms in a molecule of ammonia (NH_3) was a question on the pretest of chapter three. Eighteen students out of 53 responded that there are three different kinds of atoms. Seven students among those who were interviewed were among those 18. Each student was given a molecular formula (NaCl, $CaCl_2$, H_2SO_4, NH_3, $KMnO_4$, etc.) and asked to identify the kind of atoms in the molecule. The seven students were not able to answer correctly on the first try. They confused the kinds of atoms with the number of atoms in the molecule. Some students had problems in representing atoms and molecules by symbols and molecular formulas. The meaning of the numbers in a molecular formula was not clear to some students. Four referred to the number 3 in NH_3 as something different from both N and H, so they counted three different "things" in the molecule of NH_3. The other three students referred to the number 3 as indicating the presence of three atoms in the molecule. Identifying the elements by using chemical symbols is an important topic in chapter one. In the classroom teaching, there were plenty of examples of using symbols, but 30 students out of 53 failed to realize that NH_3 had two kinds of atoms, N and H. The interview with one student went this way:

I: How many different kinds of atoms are in a molecule of ammonia NH_3?
S: Three kinds.
I: How did you find that?
S: Here it is written 3.
I: Three of what?
S: Three atoms of ammonia.
I: Is NH_3 an atom or a molecule?
S: It is a molecule?
I: How did you know that?
S: Because atoms can't be found separately; they are found in molecules.
I: What is the symbol of hydrogen?
S: H_2.
I: Does the symbol refer to an atom or a molecule?
S: To an atom.
I: How do we refer to a molecule?
S: It is a compound.
I: What do you mean by a compound?
S: I mean more than one atom combined together in a definite proportion.
I: H is a symbol representing one hydrogen atom. What do we call H_2?
S: I do not know. What do you mean?
I: I mean that we refer to the atom by symbol and to the molecule by the group of symbols referring to the types and number of atoms in the molecule.
S: Oh, I see . . . I know what that is, but I forgot what we call it.
I: Do you mean molecular formula?
S: I think so.
I: Ok, now, how many hydrogen atoms in each molecular formula of the following: HCl, H_2O, NH_3?
S: One, two, three.
I: How many nitrogen atoms in the following: NO, NO_2, N_2O?
S: One, one, and two.
I: Very good. What are the two elements in H_2O?
S: Hydrogen and oxygen.
I: How many elements in the compound NH_3?
S: Ah, ha--nitrogen and hydrogen, only two.
I: What is the total number of atoms of the two elements?
S: One of nitrogen and three hydrogen.
I: So how many kinds of atoms are there in the molecule?
S: Two kinds of atoms.

I: Could you write the molecular formula for the molecule of ammonia and water?
S: (The student wrote it this way: NH3 and H2O, where the numbers 3 and 2 were written at the level of the symbols and not as subscripts to them.)

During the discussion of symbols and formulas, nine students showed some problems in writing the symbols, seven students did not realize the need for a capital letter O in a molecule of NaOH, two students were not able to write the formula, and only two students from the 11 interviewees were able to write the formula of sodium hydroxide correctly.

Learning about the Direction of Electron Flow

The 11 students interviewed were shown a diagram similar to Figure 4.6 and asked the following questions:

1. Is there an electrical current in this diagram?
2. If yes, what is the source of it?
3. What is the direction of Na^+, Cl^- ions in the solution?
4. What is the direction of electrons in the electrical circuit outside the battery?
5. How did the negative electrode of the battery and the positive electrode become negative and positive?
6. Do you expect electrical current to flow inside the battery?

None of the 11 students was able to realize that chemical reaction was the source producing electrons inside the battery. Only two realized that the battery itself is part of the electrical circuit where electrons should continue their flow inside the battery in order to have a closed circuit.

At least seven students did not seem to be influenced by the incorrect emphasis made by Miss Talib that electrons flow from positive electrodes to negative electrodes in the outside circuit. Five of those students were not aware that the teacher made this emphasis contrary to what the textbook said. The other two realized that, but they thought she was talking about some additional ideas to which they did not pay attention.

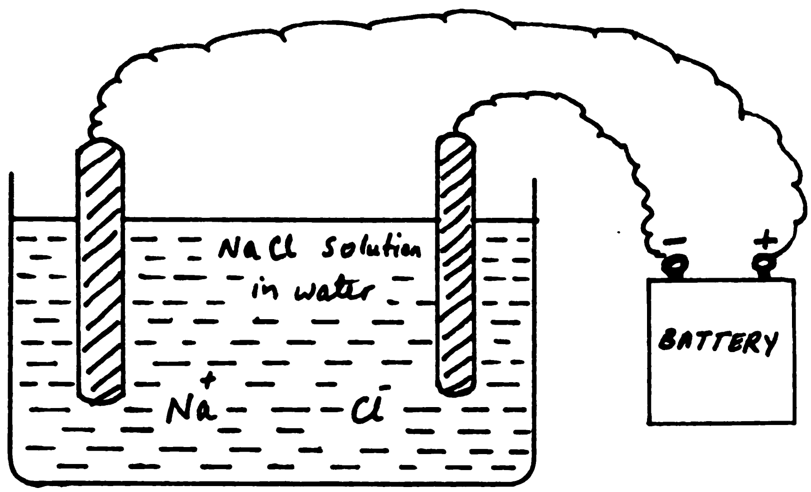


Figure 4.6. Electrical current passing through an electrolyte.

One student stated: "I did not feel any problem in understanding that from the textbook, it is clear. See?" (showing her copy of the textbook where she underlined statements about the direction of electron flow from negative to positive in five places on the same page).

The other four students were confused about the meaning of the signs (+ and -) on the electrodes of the battery. One of them expressed the change in her conception in this way:

> I used to think that the sign - on a battery means electrons and + means protons, but in this chapter, I learned that protons do not move because they are inside the nucleus. But yesterday, I learned a new thing, that the sign - means that the electrode is in shortage of electrons and the sign + means that the other electrode has an excess of electrons, and that is why electrons flow from positive (+) to negative (-).

Another student was confused by the warning that Miss Talib had made about not confusing the flow of electrons with the flow of ions.

> I used to think that anions in a solution move toward the negative electrode and cations move toward the positive, but I think that Miss Talib mentioned yesterday that the direction of the flow of electrons outside the solution in an electric circuit is opposite to that of ions inside the solution.

Boiling point and vapor pressure. A lot of time and effort was devoted to teaching the relationship between the boiling point of a pure liquid or a solution and its vapor pressure. Three multiple choice items about vapor pressure were included in the test at the end of teaching chapter two. There was also a free response test which included the following question: "Explain why a solution boils at a higher point than a pure liquid." Of 53 students in the classroom, only nine used the concept of vapor pressure in their free responses. They used the concept in different ways:

--only two responses were considered to be correct explanations; they stated that the vapor pressure of the solution was less than that of the pure liquid

--one student mentioned that pure liquid has a different vapor pressure than solution

--three students mentioned that vapor pressure of solution is higher than that of pure liquid

--two students mentioned that the boiling point of solution should be higher in order that vapor pressure should be equal to atmospheric pressure

--one student mentioned that saturated vapor pressure is a constant at a certain temperature

The remaining 44 students did not even mention anything related to vapor pressure. Almost half of them (23) thought that the high boiling point of a solution was due to "impurities" present in the solution or to the fact that the solution had more than one substance so there was a need to boil the pure solvent first then to provide more heat to cause the other substances, the solutes, to boil.

Since none of the students from the steering group provided a complete answer to the question, the investigator intended to talk to them about that. Three of them, Jamila, Nadia, and Manal, referred to the existence of another substance in the solution, the solute, and the increase in the concentration of this solute during the boiling process which requires an increasing heat and temperature. This explanation, in fact, was given in the textbook to account for the fact that the boiling point of the solution does not stay constant; it continues to rise during the boiling process. All that is required to make this answer relevant to the question was to refer to the impact of the solution on the pure liquid which causes the vapor pressure of the solution to decrease. Auraib was asked the question in the classroom (Lesson 2-11). Her response was similar to that of Jamila, Nadia, and Manal; she was reprimanded for not being able to answer correctly. Another student mentioned the role of vapor pressure, and the teacher elaborated on the answer, emphasizing that the vapor pressure of the solution is less than that of pure water, involving the class to state this fact in a choral response. Auraib, however, did not change her mind. The written answer given in the classroom and her oral answer in the interview were almost the same.

Overview of Students' Learning

It was clear that most students did not understand the nature of science as it was presented in the curriculum of the NSC. More than half of them did not realize that scientific conclusions are temporal and subject to change; 12 of them chose to believe that these conclusions should be incorrect if prevailing theories did not explain them. Most students had problems learning the laws of chemical composition, Faraday's laws of electrolysis, and many other basic concepts in chemistry and in science in general, such as the element, the molecule, solubility, and the number and kinds of atoms in a molecule. Students' performance on stoichiometry related to calculation of concentration and molarity was very poor. Similarly, the relationship between the vapor pressure and the boiling point was not understood by the majority of students.

In most cases, students have shown considerable progress in their learning from instruction as measured by the difference between their performance on pretests and posttests. This difference was a substantial one in learning the following:

1. the relationship between atomic mass and atomic number, the principles of Dalton's theory, Avogadro's hypothesis, and the properties of cathode rays; the increase in the number of students who responded correctly on these topics was 66% and more;

2. the relationship between protons and electrons, the value and sign of charge on electrons and protons, properties of ionic crystals and the concept of scientific law; the increase in the number of students who responded correctly on these topics was 38% and more; and

3. the discovery of the nucleus by Rutherford, isotopes and the role of neutrons, the concept of solution, the definition of an atom, real and ideal gas, the relationship between the mole and Avogadro's number; the increase in the number of students who answered correctonly on those topics was 28% and more.

There are a few concepts which have been learned by two-thirds of the students. These include:

--the concept of scientific law

--the definition of Avogadro's hypothesis

--the similarity of atoms of the same element

--the difference between real gas and ideal gas

--the definition of mole, atom, compound, cathode rays, covalent bond

--the formula of a compound formed by the attraction of certain ions

--the difference between electrons and protons

In a few other cases, the number of students who answered certain items correctly on the pretest has decreased on the posttest. The students, in those cases, just did not seem to learn from instruction; they became more confused. Examples of such cases are the following:

--the fact that gas laws are explained by the molecular kinetic theory

--the relationship between the number of moles and the mass of a substance

--using Avogadro's number in usual calculations

--the difference between descriptive and explanatory statements

Eight items from the test of Chapter One were repeated in the test which was given to students at the end of the third chapter. The result of test 3.2 shows an improvement in students' repsonses on three items, a decrease in the number of students who answered correctly on four items, and a similar situation on one item. Two of the items on which students' responses have improved are related to the understanding of the nature of science, while the third item was one on which 15 students of the 28 who answered correctly on pretest 1.1 changed their minds on pretest 1.2. Before instruction, many students (28) used their common sense in answering questions correctly. it seems tha they became confused after the instruction and tried to apply the number of molecules in a mole in their answer. When the same question was repeated at the end of chapter three, many of those students returned to applying their common sense and chose the correct answer as they had before. The decrease in the number of students who answered correctly on the other four items was not a sharp decrease (8% - 19%). Even after this decrease, 60% still held the right conception. After a period of three weeks, students retained most of what they have learned in these four items, retained the same learning in one item, and learned more in three items.

The items from test 2.2 related to molar concentration in solutions were repeated in test 3.2. The performance on test 2.2 related to these items (items 17, 18, and 19) was generally poor; questions were answered correctly by 26%, 45%, and 19% of the students, respectively; after a period of three weeks, responses on the same items on test 3.2 (items 31, 32, and 33) were 26%, 34%, and 32%; these responses are still relatively poor while maintaining the same level of performance in the first item a slight decrease in the second and a slight increase in the third.

Summary of Chapter Four

The three major components analyzed in this study were curriculum materials, classroom instruction, and student outcomes. The curriculum mateials are the same in all schools in Jordan. NSC was developed to explore the natural phenomena, keeping in mind the unity of science and complementarity of its disciplines and to provide students of the tenth grade with some basic skills and understanding of science. NSC consists of four units: (a) measurement, experimentation, prediction, and explanation; (b) equilibrium; (c) the particle theory of matter; and (d) energy. The unit of interest in this study was the particle theory of matter where the major theme of all five chapters in the unit was the explanation of physical and chemical properties of matter in terms of its molecular and atomic structure. The structure and organization of the knowledge in each chapter were introduced, and the approach of presentation of subject matter for teaching was also introduced. The main approach is to demonstrate natural phenomena or conduct scientific experiments, then to raise questions about the explanation of those experiments or observations and conclude the facts, laws, and theories, making a direct linkage with the applications of daily life.

The teaching activities included these interrelated phases: planning, actual instruction, and evaluation. Although Miss Talib planned for teaching her classes, she had a negative attitude toward "official planning" and toward planning for experiments and practical activities. All 26 lessons observed in Miss Talib's classroom were conducted in the same classroom except for one lesson which was conducted in the school lab. Fourteen lessons among those 26 were considered typical in format where the teacher introduced a new topic for the class. Four lessons were spent answering the chapter questions and problems. Five lessons were spent administering tests before and after the instructions. In one instance, a student was asked to make the presentation; in another case, students read aloud from the book and the teacher provided illustrations, examples, and comments. Flanders' Interaction Analysis Categories (FIAC) were used to estimate the percentage of time occupied by teacher talk or student talk. The classroom was dominated by teacher talk in all types of lesson formats, especially in typical lessons. A major feature of Miss Talib's classroom is the students' choral responses which are encouraged intentionally by the teacher, in most cases as a way of checking students' attentiveness. Most of the time spent in teacher talk was either in lecturing or in asking questions and elaborating on students' responses. Questions of Miss Talib's were mostly rhetorical, either not needing answers from students or needing a spontaneous choral response.

It was possible to distinguish among three categories of students in Miss Talib's classroom. The first category was a reference group which was comprised of the majority of students who have an average level of academic achievement;

Miss Talib intended to address this category most of the time. The second category was a steering group which was comprised of the best few students in terms of their academic achievement. The third category was a concern group consisting of students who were considered by the teacher to be the lowest in achievement. The steering group and the concern group have both occupied a considerable portion of classroom time. Most questions directed to students from the steering group were answered correctly. Miss Talib called on members of this group to answer questions very often because they were the only students who raised their hands to respond to the teacher's questions. She also directed many questions to students of the concern group to put them under pressure to study and prepare well, but most of these questions were not answered correctly.

Miss Talib was considered to be among the eight percent of secondary school teachers in Jordan who are qualified and certified to teach at the secondary level, so she felt very confident. Two major roles can be identified for Miss Talib in her classroom, both related to each other and carried out simultaneously. They are the control of knowledge and the control of social order.

Miss Talib taught the subject matter in the same sequence as it ws presented in the textbook, but she did not do any of the experiments suggested by the textbook or described by the teachers' guide, expect passing electricity in dicharge tubes to see the color of the gas in each tube. She used rhetorical questions quite often to get her students to repeat correct information as a groupl, but occasionally she also asked questions to individual students and gave seatwork assignments as part of her continuous evaluation. Official assessment of students' work was carried out by a series of tests which were viewed negatively by both teacher and students.

Students' learning outcomes as intended by the curriculum writers included cognitive, affective, and skill aspects. Miss Talib was aware of the need to develop in her students the skills and attitudes related to science. But the focus of her interest was related to cognitive knowledge of the curriculum. Students' learning outcomes were examined by looking at their responses during classroom instruction and during interviews with the researcher in addition to their performance on different tests. In most cases students showed considerable progress in learning from instruction as measured by the difference between their scores on pretests and posttests. This difference was substantial in topics which were introduced to students for the first time, such as Avogadro's hypothesis, cathode rays, isotopes, and neutrons. Students' correct responses on some items showed a decrease in posttests in topics which were answered correctly on the pretests using common sense and logic; instances of this type are related to calculating relationships between a number of moles and the mass of a substance using Avogadro's number in simple arithmetic and the difference between descriptive and explanatory statements. Instruction has created some confusion for students in those topics and reduced the number of students who answered correctly. Although most students have learned the definition of many concepts, laws, and theories, they, nevertheless, showed a poor ability to relate these definitions to major themes or general principles. For example, very few students were able to recognize the stages of development of atomic theory.

The textbook and teachers' guide did not provide direct linkages between the specifics of the subject matter and the general principles, and the teacher was not able to provide those linkages in the classroom. Although the students learned most of the specifics, they did not, however, learn the conceptual themes. There was no chance for students to learn the intended skills related to the practical work because chances were not provided for them. Students were also influenced by the general public view of science and the occasional comments by the teacher about the difficulty of learning science; therefore, they developed the same view. In addition, the tests revealed the fact that most students were not able to learn the intended objectives related to understanding the nature of science.

CHAPTER V

INTERPRETATION AND DISCUSSION

Introduction

The previous chapter presented an analysis of the three components of the study: curriculum materials, teaching activities, and students' learning outcomes. The purpose of this chapter is to discuss the main findings related to the above-mentioned analyses and to make syntheses of those findings as an attempt to develop a framework to understand and interpret the interrelationships among the various contextual factors in each of the three components. The discussion will also focus on the research methodology and the value of combining qualitative and quantitative types of evidence in the research strategy.

Analysis of the curriculum materials will be discussed first in terms of clarity of the goals and objectives, the amount of subject matter taught, ways of presentation of that subject matter, and the extent to which these curriculum materials were helpful to the teacher and/or students in achieving what they were designed for. Then the teaching activities will be discussed in light of the complexity and interrelations of various related factors which shape those activities. The students' learning outcomes will also be discussed and interpreted as a product of the teaching and learning process with an attempt to account for the level of learning various domains of instructional activities. In this discussion, some examples of the subject matter content will be chosen and traced through the three components of the study of Miss Talib's classroom.

Discussion of the Curriculum Materials

The Philosophy of the Course

The Natural Science Course for students of the tenth grade, from the perspective of curriculum developers, has been carefully developed for the following specific purposes:

1. the root of all science is the exploration of the natural phenomena which usually have aspects related to various academic disciplines, but the unity of science and the complimentary nature of its disciplines should be preserved;
2. some natural phenomena have been traditionally excluded from the three major disciplines (chemistry, physics, and biology) and related to other areas such as geology, astronomy, meteorology, oceanography. Since some of these natural phenomena are considered important, there should be a way to include them in the secondary school science curricula; and
3. all secondary school students need some basic science skills and some understanding of the meaning of science at an early age before they consider dropping out or before they are channeled into science and literature curricula.

As a result, the natural science course tried to achieve these goals. It was built on a

> . . . solid science base to help the student to interact efficiently with his environment and society and to pursue the study of science in various fields. This scientific base tried to show the unity of science and complementarity of its disciplines. The various topics were combined together and related to few conceptual schemes which represent unifying ideas that cut across all sciences and help the student to achieve a comprehensive perspective about things, events, and phenomena around him (Malkawi, 1972).

Three major conceptual schemes were identified to be essential in various science disciplines: equilibrium, energy, and the particle structure of matter. They were considered the base for combining many categories of science concepts and theories and the framework of the organization of subject matter. The nature of science and its major activities were also considered essential goals to be presented at this level.

The content of the units is shown in Appendix A. The major theme of all five chapters in this book was to show that physical and chemical properties of matter are explained by the molecular and atomic structure of the matter.

Students in the tenth grade have had science before and were familiar with such concepts as atom, molecule, element, compound, chemical reaction, etc. This unit, however, started from a point which assumed that no previous theoretical knowledge would be necessary. Students would be expected to reorganize their preconceptions about the structure of matter in a new framework where all concepts and ideas should be interrelated within major conceptual schemes in which properties of matter could be understood in terms of its molecular and atomic structure.

Students should have been exposed to the nature of scientific activity in the first semester. In this unit they learn the structure of matter as an example of where scientific knowledge comes from and what it means to explain this knowledge. These two points comprise the main purposes of Chapter 1 and most of Chapter 3, while Chapters 2 and 4 are devoted to the using of knowledge already developed in some examples of scientific applications in daily life and societal needs. Chapter 5 is a unique intellectual exercise. The periodic table of elements is considered a very simple, very successful way of organizing the huge amount of scientific knowledge about elements which also facilitates the study of this knowledge. The chapter starts from the periodic table as it stands in its present form, analyzes various groups and periods of the table, and relates all that students have already learned from previous chapters about the structure of the atom and electron configuration to the regularity and periodicity of properties of chemical elements.

There is a strong emphasis in the introduction of the textbook and the teachers' guide to relate regularities and consistency of patterns in chemical behavior to an accurate image of science where underlying patterns of scientific knowledge have certain meaning, limitations, and purposes. The major assumptions here are derived from various sources, including the Jordanian philosophy of education and Islamic values of the society and culture.

Among these assumptions is the view that the whole universe was created for a purpose. By his very nature, man is an intellectual creature and his life as part of the universe has a certain meaning. Everything is well organized, in a state of harmony with everything else, and in a beautiful order. Nothing has come by chance; nothing has developed randomly.

Science is an essential human activity by which man tries to achieve the basic knowledge necessary to understand and explain the natural phenomena and to realize the regularity, consistency, and aesthetic aspects of this universe (Abanda et al., 1974, p. c). Since things of this universe are subject to the exploitation of man, he has to know more about them in order to use them to develop better quality of life. Nothing prevents him from doing that except his ignorance, nothing will help him more than acquiring knowledge. As he is building his scientific knowledge, he is also building his own understanding and developing continuously new meanings of his own life and his environment (see Figure 5.1).

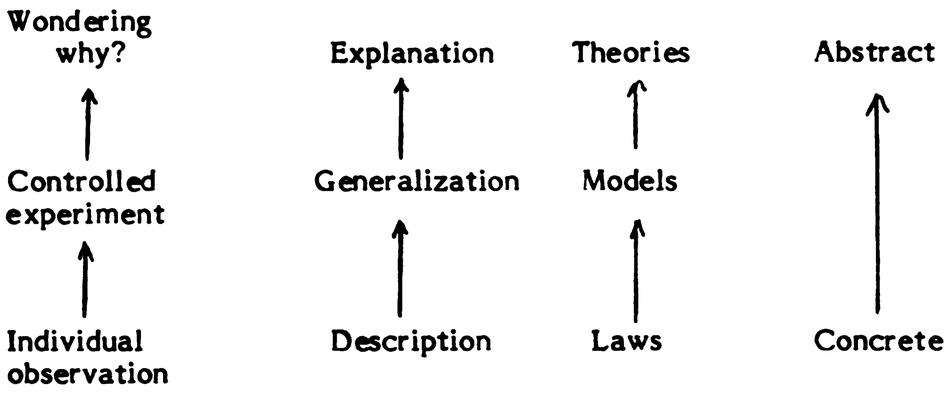


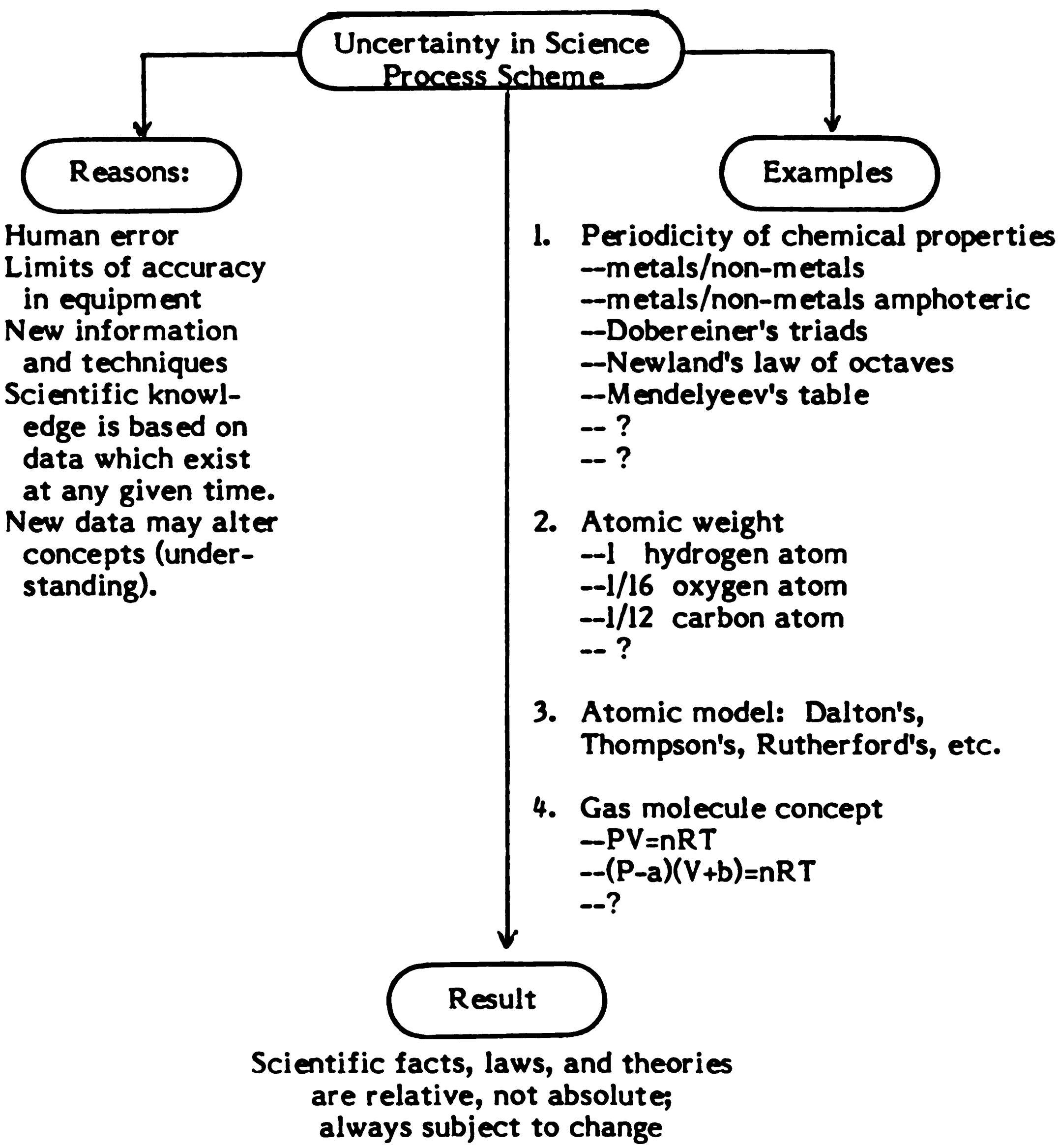
Figure 5.1. Building scientific knowledge and human understanding.

Along with the conceptual scheme which represented the framework of the subject matter of unit three, teachers also are oriented to a certain set of process schemes to be acquired by tenth grade students as a result of learning the required content through suggested processes. These process schemes are:

1. to accumulate data through observation and experiments,
2. to organize the gathered data in order to search for regularities and patterns,
3. to explain the regularities by using a model system,
4. to understand the relationship between description and explanation,
5. to recognize and understand the absence of certainty in scientific knowledge and its temporal nature, and
6. to recognize the difference between the physical realities of things and the conceptual constructs that people develop to understand these things (Malkawi, 1975, p. 3).

It was also suggested that teachers should refer to these schemes at the beginning of the lesson to establish a relevance of the topic to be learned and facilitate students' understanding. The main conceptual scheme and the other process schemes related to it represent the cognitive structure on which to build meaningful learning of the topic's details and to achieve a higher level of abstraction. One example is presented in Figure 5.2. It relates a network of concepts to process scheme No. 5 about recognizing the uncertainty in scientific knowledge.

Figure 5.2
One Process Scheme Related to a Large Network of Concepts



In discussing the philosophy embedded in the unit of properties of matter and the particle model, at least two main questions should be addressed. First, was this philosophy evident to teachers when they used the curriculum materials? Second, what are the consequences of the fact that this unit was basically a part of the chemistry curriculum which has been adopted originally from the American Chemistry Project (CHEMS)?

Miss Talib's Awareness of the Philosophy of the Curriculum

There was no evidence that Miss Talib had seen the curriculum pamphlet or the teachers' guide before meeting with the researcher. In her response to the questionnaire which was sent to her by the researcher (Appendix N), she indicated that she does not use the teachers' guide. In fact, 10 teachers of the 18 who responded to the same questionnaire indicated the same fact. Six of those 10 indicated that they were never informed that there was a teachers' guide. But even those who knew about it later on, such as Miss Talib, did not find it very useful. For example, Miss Talib described the teachers' guide as follows, "All that it includes is the experiments . . . the objectives are there also, but the objectives are known anyway . . . I did not read the teachers' guide literally. I just looked at it and saw what things it has."

It seems obvious from Miss Talib's several comments on the value of the teachers' guide that this document as it stands failed to convey the authors' perspectives to Miss Talib and the points the authors' emphasized were not those which Miss Talib usually looks for in a teachers' guide. The authors' intentions were not explicitly expressed in the teachers' guide because the decision was made not to convey specific suggestions which might stand as a barrier to teachers' creativity. Teaching methods' literature, especially in science teaching, contains a great deal of criticism toward "cookbook" and "spoon feeding" types of suggestions. Furthermore, the authors were afraid that specific suggestions might not match the special circumstances of teachers and schools. The overall suggestions in the teachers' guide regarding the teaching of each chapter in general were not helpful to Miss Talib, especially identifying the instructional goals of each chapter and procedures for doing experiments. Instructional objectives need to be addressed through the teaching of specific topics where there is no "guide," and just identifying those objectives and listing them was not seen as a great job. As far as detailed descriptions of how to conduct experiments is concerned, there was not place for doing experiments in Miss Talib's classroom, so she was not seeking help in this regard.

The teachers' guide has only a few suggestions with direct relevance to specific topics. For example, it suggested not spending much time on discussing laws of chemical composition and on doing numerical problems regarding those laws because this topic was presented again in the twelfth grade chemistry curriculum. What was intended here was only to refer to those chemical laws as evidences for the particle structure of matter. Numerical problems were not intended to be worked out by every student in the classroom. The targets of those problems were the well-advanced students who needed to be challenged by more than tasks designed for average students. There was no time frame suggested in the teachers' guide for teaching the laws of chemical composition or for any other topic.

The introduction of each chapter in the teachers' guide had a brief description of the nature of knowledge in that chapter and the way in which this knowledge has been developed in the chapter with an attempt to build it on the knowledge of the previous chapter and to link it to the general theme of the whole unit. Miss Talib, however, did not refer to these introductions as a source of guidance in the teachers' guide; for example, none of the questions suggested in each introduction was used by Miss Talib in her classroom teaching. Those questions were suggested by the authors to help teachers establish a relevance for the chapter with some application to daily life and to achieve a state of interest and motivation in the students for learning the topics of the chapter.

As far as the view of science is concerned, Miss Talib frequently repeated statements from the textbook about the view that scientific knowledge is temporal and subject to change; but the way she introduced this view and the way most students learned it indicate two major misconceptions regarding the philosophy which the curriculum tried to emphasize. These misconceptions are:

1. scientific concepts such as the mole, atom, ion, etc., were used in the classroom in a realistic way so that the concepts were perceived as real objects and not intellectual constructs; and

2. the change in scientific knowledge was seen as replacement of an old "wrong" knowledge with a new "right" knowledge. Dalton's model of the atom, for example, was viewed as the "wrong" model, the "incorrect" and "faulty" one, so it was replaced by Thompson's model. And when Thompson's model "was found also incorrect, it was discarded and became no longer the right model; it was replaced by Rutherford's model which is considered the right model now" (Miss Talib, Lesson 3-4, March 4).

The garbage collector analogy in the first chapter of the teachers' guide (see Appendix H) was written to convey the idea that no one had seen the atom in a direct way and that the concept of atom is not something to prove the physical existence of; it is an intellectual model developed by scientists to help in understanding some observations, and scientists found various evidences that this model was adequate. This analogy was not discussed in Miss Talib's classroom.

Topics in the textbook were organized in way which helped reveal the structure of knowledge regarding the atomic model. Explicit statements were found in several places, indicating the temporal nature of scientific facts, laws, and theories; uncertainty of scientific measurements; and the nature of scientists' work. But the implicit structure of the unit and explicit statements were not sufficient to enable Miss Talib to "discover" the intentions of the authors.

In her response to the researcher's initial questionnaire (see Appendix N), Miss Talib indicated that she did not face any problem in teaching any topic of the NSC. In an interview, she indicated that whatever the method of planning for teaching might be and whatever the extent to which she used the teachers' guide, she felt that she "treats everything as it should be taught" and she "never asks for help." One way of interpreting this level of confidence that Miss Talib feels for herself is the way in which she understands what she reads in the teachers' guide or textbook. For example, she excludes from her teaching any statement or suggestion not related directly to the content of the topic or she translates the meanings of these statements and suggestions into a language derived from her own concerns. She excludes activities that need time beyond the time limit of the school day and that effort which is needed to present materials in the classroom and prepare and grade tests and examinations. She thinks she does not have time to prepare required experiments except after the end of the last lesson in the school day, and she does not feel obliged to do so "because it is not included in the contract" with the Ministry of Education.

Another way of interpreting what Miss Talib does regarding using curriculum materials is that she does not "read into" the curriculum materials that which is not written there. She taught the stages of the development of the atomic model as they are found in the textbook, and there is no place in the text where the stages are discussed together to find some kind of relationship. All statements and examples relevant to uncertainty in scientific knowledge are presented in the textbook, but there is no specific topic to deal with this as a separate issue to draw general conclusions; so Miss Talib did not understand why one should spend time on such "additional" ideas. "If you think these ideas should be discussed, why did you not write them explicitly in the textbook?" (occasional comment, March 8).

In brief, the philosophy of the curriculum and the view that curriculum tried to convey, as seen from Miss Talib's teaching behavior are located in the written words of the textbook and not the teachers' guide and the meanings of those words that she assigned can be interpreted in terms derived from her own experience.

Some Issues Related to the Design of NSC

The unit of properties of matter and the atomic model in NSC was originally parallel in its content to the first seven chapters of the American CHEMS. The topics of this unit were supposed to have been reorganized to fit in the NSC by including in them some applications of the basic concept in other disciplines, physics, geology, etc. But the unit as it stands in this course was not perceived by Miss Talib as more than a chemistry unit. She introduced the unit in the first lesson of the second semester, saying, "Today we will start 'taking' the second volume of natural science course; we will begin studying the chemistry unit: properties of matter and the atomic model" (Lesson 1-1, January 27).

Since Miss Talib has a degree in chemistry, this unit is a favorite one for her; but this is not the case for other teachers who do not have university degree or who have degrees in another discipline, as seen in their responses to the questionnaire of the curriculum department in 1981. One frequent suggestion in those responses was to break down the course into its original disciplines and have three different courses in chemistry, biology, and physics.

The unit in this course on properties of matter and the atomic model included many basic chemistry concepts. Table 4.1 listed the number of concepts among the instructional objectives to be learned in the first three chapters of the unit. One problem mentioned by 12 teachers of the 18 who responded to the researcher's initial questionnaire, including Miss Talib, is that there is too much material to be covered in the time available. When the researcher discussed with the principal of the Northeastern Girl's Secondary School the reason for not using the laboratory, she referred to the NSC as an example and said that all teachers who taught the NSC in her school reported to her that they were not able to cover the "theoretical part of the materials, not to speak of the experimental part" because of the shortage of time. This problem has been cited repeatedly by teachers, as though the curriculum developers miscalculated the time required to cover the material. In fact, the curriculum materials failed to make explicit reference to the fact that many experiments and practical activities could be done and discussed in such a way that students can understand the concepts easier and perhaps faster than just discussing them in theory. Some experiments were presented in detail in the teachers' guide to help teachers who had limited experience and training in laboratory work. Properties of gases, for instance, cannot be studied practically without preparing the gases. To prepare each gas, an apparatus should be constructed. This process needs some experience in cutting and bending glass tubes, making holes in cork or rubber stoppers, using a Bunsen burner, and many other techniques and safety precautions. Another assumption underlies these details: the fact that teachers cannot find available sources of gases; therefore, they have to go to the trouble of preparing them from chemicals.

Judging from the experience of the researcher in conducting the experiments of the first three chapters of unit three of the NSC in a school setting similar to Miss Talib's, the time required from the teacher to do these experiments as demonstrations was estimated to be 14 lessons. This does not include the time required for the teacher to prepare equipment and try out the experiments before doing them with the class. It is reasonable at this point to admit that the curriculum developers were too ambitious in requiring teachers to teach and students to learn all of the content of unit three in one-half a semester.

The process of borrowing from foreign educational experiences such as adapting CHEMS to Jordan did not seem to have been sensitive enough to consider the basic differences in school setting, teacher preparation, and other societal and cultural aspects. If the total resources developed to help teachers who teach CHEMS in the USA, including the quality of the textbook, teachers' guide, lab manual, additional supplementary materials, films, charts, lab equipment, etc., besides the special training of those teachers and the quality of school and classroom physical arrangements, were taken into consideration, then it would seem to be unfair to require the Jordanian chemistry teachers and students to deal with almost the same subject matter of CHEMS while they are deprived from some of the key resources identified above. The problems of this cultural borrowing might also be found in the difference between the basic assumptions of the borrowed material and the beliefs and value systems of the society. The discussion of the case of adapting CHEMS in Jordan is beyond the scope of the present study, but it is an issue which is worth investigation in future research.

In summary, the goals and objectives of this part of the chemistry curriculum in Jordan (the unit of properties of matter and the particle model) are similar to those of CHEMS. But the quantity of the subject matter expected by the curriculum developers to be covered in half a semester, the lack of adequate lab equipment, the large number of students in the classroom, and the poor teacher preparation programs make it difficult for teachers to teach and students to learn those prescribed goals and objectives.

Interpreting and Discussing the Teaching Activities

Planning for teaching, for Miss Talib, has a simple meaning. It is a natural step of knowing what to teach by reading the textbook. She does not have to worry about how to teach the material because she knows how to talk about it. Sometimes she might use a certain procedure during the lesson which she never thought of before. When this occurs, it becomes worthy of recording in the lesson plan she writes after the lesson has been taught. Writing lesson plans is not an important activity because it is not meant to be used by the teacher. It is something to show other people, a written evidence that the teacher plans for teaching. For this reason, the plan that Miss Talib writes in her planning book is not meant to be implemented in the classroom. She describes very well what is required for inclusion in a lesson plan; she learned this in her graduate studies in education. Her written lesson plans also reflect this knowledge.

The number of written plans she must do each day was negotiated with the principal, and she does not have to write plans for every lesson. A negative attitude toward writing lesson plans was interpreted by the fact that she viewed this planning as a time-consuming process which does not have much impact on the teacher's performance in the classroom. It is just "routine work with no meaning." For a written lesson plan to have more meaning for Miss Talib, it should be written after the lesson is taught "to document the activities which have proved to be working and to report the material that has really been taught in that lesson."

Using the teachers' guide in preparing classroom teaching or thinking about the experiments and practical activities were not among the main practices of Miss Talib's planning procedures because the teachers' guide did not help her much and the time she had available for teaching did not allow "wasting" any moments in trying experiments which "might not work."

Lesson formats in Miss Talib's classroom were basically systematic presentations of new topics in the same order and sequence as found in the textbook. Student's learning in these "typical" lessons was reinforced by assigning some lessons to review the topics, answer the chapter questions, or work out some problems. Student's learning was also evaluated in other lessons assigned for exams. In a few instances, Miss Talib made some changes in the lesson formats from what had been typical for her. In one instance she assigned to a student the task of presenting a new topic. In another instance she asked the students to read aloud from the textbook, then she made some illustrations and comments after reading each paragraph. In the third instance, the lesson was given in the laboratory not in the classroom, and she spent some time doing a demonstration. Whatever the format of the lesson might be, teacher talk was the dominant feature in the classroom interaction. Another major feature of the classroom interaction was students' choral responses to certain types of rhetorical questions from the teacher.

Miss Talib thinks of herself as an active teacher because every minute of her classroom time is used in teaching the subject matter, almost all types of verbal communication are related to subject matter. She gets the attention of all students and does not allow any student to lose her attentiveness to the classroom task. Students' choral responses were seen as an evidence of their attentiveness. Classroom time had no place for exchange of feelings or talk about outside topics; "teaching is a serious business." She was always standing or moving, never sitting in her chair to rest.

To decrease the amount of lost time in her classroom, Miss Talib adopted the lecture method of teaching.

> But it is different from usual lectures at the university level where students are just listening and writing notes. Here I involve students in reacting to my presentation, and I use many questions where students have to respond individually or collectively (Interview 2, February 10).

Again the time was seen by Miss Talib as a rationale for adopting the lecture method. It is a more effective method than others for transmitting more knowledge in less time. Assigning a review lesson to answer chapter questions seems to be more economical in time investment than reviewing each topic individually. This also explains the very short time of "introduction" and "conclusion" of most lessons. Students are required to read the topic of the lesson from their textbooks before the lesson is presented. In doing so, they become familiar with the content which enables them to understand it quickly in the classroom. "The more the students prepare well (in reading the material) at home, the smoother the lesson becomes and the less time is required for them to understand."

Miss Talib realizes that not all students in the classroom will understand the topic at the end of the lesson because some students are slow learners who need more time to be able to understand. She also realizes that she can help those students by repeating the explanation once or twice, but "I have no time to wait for them; they have to raise their levels to the average."

She tried in various instances to explain most of her teaching behaviors in terms of shortage of time, not only those behaviors related to planning and preparation for teaching and to the instructional method, but also those related to quality of social relationships, to the practice of power and control in the classroom, and to the procedures of evaluating student learning. The school principal sympathesizes with Miss Talib in her complaint about shortage of time, but she admits that this kind of feeling is the "tax of the teaching profession" when compared with other professions. However, Miss Talib is still single. According to the principal, "If Miss Talib has all these complaints, what do you expect from those teachers who are married, who have to worry about cooking for their husbands and taking care of their children and meeting the demands of more social responsibilities?"

It seems that the principal's term "tax of the teaching profession" has more than its literal meaning. It refers to the injustice and frustration that teachers feel as a result of the disproportionality between the moral and social responsibilities and demands of the teaching profession on one hand and the lack of support, low incentives, and declining social position of the teacher on the other. This feeling of injustice is a general mode which contributes to negative attitudes toward the profession itself and creates a low morale among teachers in general. Science teachers as a subcategory in the profession are influenced more by this situation than others because they feel that the demand of preparing for lab experiments is added to the responsibilities they share with other teachers, as indicated by the principal of the Northeastern Girls Secondary School when she quoted a science teacher in her school saying, "Is my specialization in science going to be a punishment for me?"

Interpreting and Discussing Student Learning

From Miss Talib's point of view, all students can learn the concepts of the curriculum provided each one can devote the time required for him/her to understand certain concepts. In her view the difficulty that some students encounter in learning science is not embedded in science itself, nor is it that those students cannot learn. If a student has the prerequisite knowledge to learn certain concepts, then the new learning can be related to the previous learning, making it easy for him/her to develop a special meaning of the new concepts and retain the new learning.

Miss Talib referred to the importance of prerequisite knowledge in student learning in various instances. In reviewing Chapter 1, lesson 1-6, she told the class that "you should not forget the concepts you have learned in this chapter because you need them as a base for learning the following chapters."

In lesson 2-7, Miss Talib asked the class as homework to write down formulas of compounds which are examples on both ionic electrolytes and molecular electrolytes. In reviewing students' responses in the next lesson (2-8), she found that students were very confused. Her sister Nadia, a student in the classroom, asked:

Nadia: How can we know whether a compound is ionic or molecular?

T: This is the question! When the bond is ionic which means that one atom has the tendency to lose electrons and the other atom has the tendency to gain . . . (she was interrupted by another question)

Nadia: And how can we know which atom is going to lose and which one is going to gain?

T: From the configuration of electrons. We go back to see whether the bond is ionic or covalent . . . (she went on to describe the difference between the ionic and covalent bonds, then made the statement:) All your homework was done incorrectly and you have to do it again for next time.

In lesson 3-5, when Miss Talib taught electron configuration and kinds of chemical bonds, she referred to Nadia's two questions and said, "You know now after understanding this background about the distribution of electrons and the types of bonds; how to give examples of ionic and molecular electrolytes"; then she made another relevant statement, "Remember, class, this information (electron configuration and chemical bonds) is very important, especially if you are going to be in the science branch. There are many things you can't understand in chemistry unless you know the bonds" (Lesson 3-5).

Prerequisite knowledge, however, does not seem the only factor affecting student learning in Miss Talib's classroom. Time plays a role in students' learning. Some students learn when they listen to the teacher's explanation the first time; other students need repetition. "Sometimes I repeat the explanation for the second time because students from Type C cannot understand from the first time, but I cannot do that always because I have no time. I cannot wait for the slow learners; they have to raise their level to the average." In another instance, she said she realizes that as she repeats, more students will be able to understand and learn. She quoted a proverb which says, "Repetition teaches the donkey."

A third factor seems relevant also in student learning. "There are students who learn directly from the textbook, but most students learn from classroom instruction." Miss Talib said that she uses a variety of activities in the classroom because she thinks students learn in different ways. Data are not available to the researcher to know what Miss Talib means by "different ways": different strategies of learning or different time required to accomplish learning a certain task? But she relates this concept to her attempt to use different methods of teaching in combination with the main method, the lecture.

In brief, Miss Talib was not happy at the low level of student learning, but she did not find it surprising because she realized that students come with different levels of prerequisite knowledge, they devote different amounts of time in trying to learn, and they make use of the classroom instruction in different ways. In the following sections several examples of teaching and learning certain topics were discussed in some detail.

Teaching and Learning about the Nature of Science, Attitudes Toward Science, and Scientific Skills

This relatively low level of understanding the nature of science in Miss Talib's classroom might not be a special case. Learning the nature of science and developing positive attitudes toward science and scientific activities were not viewed by many Jordanian science teachers as attainable goals by direct planning. If a science textbook has a certain chapter devoted to the development of some understanding of scientific activities, this chapter will not be given time in the classroom and will not be considered important. Students will be asked to read the chapter on their own. "The unit talks about science, but it is not science . . . science is something like energy transformation, electron configuration, and cell division. By studying science itself, you get a better ideas about it" (comments of a science teacher on the first unit of the Natural Science textbook, volume 1).

In 1981 the Curriculum and Textbook Department of the Ministry of Education in Jordan distributed a questionnaire to be filled in by teachers of natural science at the tenth grade level. Science supervisors were also asked to choose the best teachers in their districts to write reports on their suggestions and recommendations about the course and the textbook. Twenty-three such reports were received, and the researcher had the opportunity to examine them. Most of the teachers who wrote these reports consider the first unit of the textbook, volume 1, to be not important and not worth the large number of pages it has (see the content of this unit in Appendix A). A frequent comment in the reports about the unit was, "So many pages, very little content; can be summarized in few pages."

Since 1960 the Ministry of Education in Jordan has been applying the system of branching students into science or literature at the end of tenth grade.

When this system was started, only those who had average scores in mathematics and science courses which exceeded 75% were allowed to be in the science branch. The researcher was among the group of students who were chosen to be in the science branch in the academic year 1960-61; only 14 students out of approximately 120 were channeled into the science branch in the city of Zarka. The number was too small to provide a classroom with the necessary, qualified science teachers and equipment for a laboratory, so the Ministry of Education opened only three sections for the science branch to accommodate all the students coming from an area covering three school districts at that time.

This kind of academic evaluation of students in terms of their abilities to perform well in science courses at the tenth grade, besides the official and social perception of science-related professions, has created a certain conception of the nature of science, besides feeling and attitude toward science as being a more difficult subject for study than other subjects. Students are definitely influenced by this public view. Their understanding of science and their attitudes toward its study will be affected, especially if they find that the school system and teachers' attitudes conform with that view. There was no evidence that Miss Talib was an exceptional case in this regard. The few instances in which she tried to show her concern about building positive attitudes toward science in her students were not sufficient to achieve this goal, especially in the presence of other instances which displayed a negative attitude, whether in the classroom or in the society at large.

An example of how teachers usually view the students' learning of <u>scientific attitudes</u> is related to the experience of the researcher with 18 teachers of NSC for the tenth grade which formed one section of trainees in a summer course in 1976. In discussing scientific attitudes as a learning outcome of NSC, the researcher asked the teachers to list five scientific attitudes. The most frequently listed attitudes were the following:

1. curiosity,
2. habit of patience and perseverance,
3. scientific reading,
4. deliberate reflection before making judgments, and
5. appreciation of efforts of scientists.

The teachers were asked to list the number of instances in which they tried to help students develop any of those attitudes and the time they spent on each instance. The responses indicated that the time and effort devoted to such goals of science education are almost negligible. The main reason given by these teachers was that such goals are not meant to be developed directly; they are a byproduct of learning scientific knowledge itself.

Attitude learning is not likely to develop unless the teacher allows it to develop. A teacher who provides his/her own answers for every question and relies on his/her own understanding of the content presented in the textbook as the final authority is not expected to provide students with a chance to develop curiosity, open-mindedness, or willingness to suspend judgment.

Skill learning in Miss Talib's classroom is similar to the situation of attitude learning. Learning certain scientific skills is expected to be directly related to doing practical activities. If students do not have the chance to do such activities, to be involved in solving problems, and to finding out about things, using their senses and pieces of equipment to employ certain procedures, the skill and process aspect of learning science is not likely to develop. Students in Miss Talib's classroom did not have the chance to practice any practical activity. Ten teachers in six different schools in the same district where Miss Talib's school is located were asked by the researcher about the number of experiments in which students were involved in manipulating equipment and materials during the period of studying the first three chapters of the "particle theory of matter" unit. None of those teachers reported any experiment of this type. Three teachers, however, reported doing demonstrations in front of the class. Pressure to cover the content, shortage of equipment to be used by students, time needed to prepare for and try the experiments, lack of confidence in doing successful experiments, and the large number of students were factors suggested by those teachers to account for the phenomenon of not conducting practical experiments.

Teaching and Learning the Direction of Electron Flow

This example is a good case of how the teacher translated the curriculum material and assigned certain meanings to it which are different from their literal meaning. The topic in this example was electrical conductivity and its explanation in terms using knowledge learned from the structure of matter after the development of Rutherford's model of the atom. One and one-half pages of the textbook were devoted to explaining how static electrical charges are formed by friction on plastic and glass when they are rubbed with wool and silk, respectively, and how these charges are discharged. Chemical reaction in an electrochemical cell (battery) was given as another source of the formation of electrons. When the two terminals of the battery are connected to each other by a conductor, electrons flow from the terminal where they accumulated in large numbers (called the negative terminal) to the terminal which has a shortage in electrons (called the positive terminal). The conducting wire can facilitate the flow of electrons in its atoms which can be pushed in a certain direction forming an electrical current where the battery provides a continuous flow of electrons.

The easier electrons can move from the conductor, the higher the conductivity it has for electrical current.

In her teaching, Miss Talib did not make any reference to the chemical reaction as a source of electrons. She emphasized two points--the concept of a closed circuit as a condition for the flow of electrical current and the direction of electron flow from the positive terminal of the battery to the negative terminal.

Miss Talib's emphasis on the direction of electron flow is in a way contrary to what is stated in the textbook which caused confusion for some students. In fact, Miss Talib did not realize the difference between what was written in the text and what she was emphasizing. Two students, Rana and Hamama, questioned her statement and referred to what was written in the textbook, but she did not even realize her mistake then.

One factor in interpreting what happened to Miss Talib in this instance is that she did not read the topic carefully before the lesson. Her lesson plan of March 9 had only two points. The first is related to the objectives of the lesson: "to understand and be able to explain electrification and electrical conductivity and to know what the forces of Van der Wall are." The second point is written under activities and methods of presentation: "One student will read aloud, then make comments on some points" (see Appendix Mb). She assumed that this lesson did not have new material, that it was "just a review" of some topics which were studied earlier in Chapter 3 of the textbook. The lesson was "just explanatory of something we took before." She made this comment three times during the lesson. This orientation toward the topics of the lesson seemed to make the teacher less careful about what she was reading or hearing from students as they read aloud.

Another factor which contributed to this misconception is the fact that electrical current was conventionally described in physics courses and textbooks in a different way than that of the flow of electrons. Electrical current by convention flows from the positive terminal of a battery to the negative terminal, opposite to the direction of electron flow from negative to positive (Appendix O).

There are no data available regarding what students in this classroom learned about the direction of the electron flow in the third chapter's test in order to analyze the effect of classroom teaching in this particular case. The responses of 11 students who were interviewed by the researcher about this case might be representative of the student learning of the whole class. It is interesting to note that some students who learned from reading the textbook were not confused by the teacher's emphasis on what was contrary to what they had learned. What they had learned was meaningful and became personal knowledge which made sense for them. Even the two studies who realizd the conceptual conflict (Naussbaum & Novich, 1982) between their acquired knowledge and that presented in the classroom instruction were not confused.

A similar example of how Miss Talib assigned certain meanings which is different from that implied in the curriculum materials was her statement about the standard temperature (temperature of the standard conditions, STP). She mentioned that this temperature is 20 Celsius, but the correct temperature is 0 celsius. Twenty degrees Celsius is, in fact, the temperature at which voltages of electrochemical cells for various electrodes were measured at conditions considered to be in the standard state, as described in the textbook of chemistry for the twelfth grade.

Teaching and Learning Laws of Chemical Composition and Faraday's Laws of Electrolysis

Miss Talib did not feel comfortable with classroom interaction during the period of teaching the laws of chemical composition. This might be explained at least in part by confusion about the place of the topic in this unit. In the traditional textbook written in Arabic and English, laws of chemical compositions were presented as a chapter or a major topic with plenty of numerical exercises and worked out examples. Chemistry of this type is turned to stiochiometry where students acquire the skill of working out numerical problems without getting into the meanings of those problems as related to chemical concepts and theories. This phenomenon was observed by other researchers (Kass & Wheeler, 1979; Rennie, 1981). Laws of chemical composition in this course were presented as a source of information about the structure of matter. They were viewed as chemical evidences for the atomic theory. The atomic theory proposed by Dalton was an attempt to explain why these laws should exist. The teachers' guide emphasized the goal of this topic and suggested the teacher not spend too much time providing exercises and problems on this topic, emphasizing instead the central relationship in each law. The textbook, however, does not seem consistent with this suggestion, because it offers two mathematical examples on each law and one more complicated problem on each law in the chapter questions, providing stronger evidence for the teacher and students about the weight of this topic in the course. Some examples and problems are not well chosen, and there are some printing errors which add to the confusion. With this situation in mind, Miss Talib was not able to avoid the confusion. She tried to follow the style of presentation of the textbook which requires memorizing definitions. In order to try a different style, she needs to have a better understanding of the topic to be able to provide more meaningful statements.

A similar example of confusion occurred in teaching and learning the laws of chemical composition is the topic of Faraday's experiments of electrolysis which was also intended to be the chemical evidence for the electrical nature of the atom. The objective of introducing this topic, according to the teachers' guide, was to show that matter has an electrical nature and that there is a relationship between units of matter and units of electricity. The teachers' guide explains the procedures of doing experiments of electrolysis in some detail and illustrates the quantitative relationship among the mass of the precipitated substance and the number of amperes, the number of seconds, and the number of coulombs. A confusing idea presented in the teachers' guide is the concept of equivalent mass instead of atomic mass. Miss Talib devoted lesson 3-1 to explaining Faraday's experiments. She also spent about 10 minutes of the following lesson (3-2) to review Faraday's laws and state the important conclusions of Faraday's experiments. Appendix E shows extracts from the two lessons. Student participation was very low, and most of their responses were incorrect.

It is expected that if students are going to learn something from classroom teaching, they will face some points of confusion. A detailed illustration about calculating the quantity of electricity has relevance if the experiment was conducted practically. But for the purpose of establishing a relationship between units of electricity and units of matter, there was no need to spend much time and not be able to follow the misconceptions held by some students about the topic. For example, Buthain was one of only three students who thought they knew the relationship between time and current intensity, but she stated this relationship incorrectly and the teacher did not correct her.

Miss Talib went into some detail in calculating the quantity of electricity required to precipitate certain quantity of an element. Several errors were made in the process. Buthain responded incorrectly to the teacher's question about the relationship between time and current intensity, and the teacher did not realize her error.

The relationship between atomic masses of elements and the masses precipitated from those elements in the experiment of the second law is not a direct proportion as stated by the teacher. Depending only on the chosen data on the board was not sufficient to establish this generalization. Even the chosen data themselves did not lead to this conclusion. The teacher's confusion came from the fact that there is a direct proportion between the mass of the precipitated element and its equivalent mass, not its atomic mass.

The decision of the curriculum developers and textbook authors for the tenth grade natural science course and the twelfth grade chemistry course was not to introduce the concept of the equivalent mass because it would not be helpful for any purpose. Miss Talib teaches both these grades, and she did not use this concept at any point in her presentation, except in the last 13 seconds (see the last two statements of the extracts from Lesson 3-2, Appendix E). During these concluding seconds, four problems can be distinguished.

1. Miss Talib did not use the concept of equivalent mass in defining Faraday's second law; she said she did.
2. Students responded positively to the question, "Didn't we say that?" This positive response has no base. The only reason for this spontaneous response is the fact that students have met the teacher's expectations, and it did not cost the students anything. If such a situation was about a procedural issue which requires

students to be responsible for something, they might argue about it, as they did in the final 10 seconds of Lesson 3-1.

T: Your lab book should be with you.
Ss: (Noises; students were surprised by this and looked at each other.)
T: I asked you to get them in the first semester, the "tabia" notebook.
Ss: You did not ask us that!
T: Yes, I did.
Ss: No, you didn't (end of Lesson 3-1).

3. The second statement, "When atomic mass increases, the quantity of precipitated substance is increased," is expected to be explanatory of the first statement, "The quantity of the precipitated substance is in direct proportion to the equivalent mass, did not we say that?" As a matter of fact, it has no relevance.

4. The second statement is incorrect anyway.

These two examples of examining student learning of laws of chemical compositions and Faraday's conclusion about electrolysis of solutions, as seen in the classroom interaction, were chosen because the classroom teaching paid more attention and time than intended by the authors of the textbook.

Miss Talib and Abu Zaid Al-Hilali:* a General Overview

While coming downstairs from the classroom after finishing lesson 3-7, Miss Talib made a statement which might be an oversimplificaiton of her situation, but it seemed useful in capturing the sense of her practices and in understanding the various actions of her tenth grade classroom. She said, "In my classroom, I am Abu Zaid Al-Hilali." The conversation which provided the context for that statement went this way:

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*Abu Zaid Al-Hilali is the name of a fictitious hero who was presented in old Arabic fables as always victorious and in control of all circumstances.

Researcher: I was the cameraman today. Since this lesson was the last to be videotaped, I tried to take shots of all features of the classroom. I tried also to focus on all students and document their attentiveness in this lesson. What fascinated me the most was the complete attention of all students and their readiness to respond to your quesitons . . . (he was interrupted by the teacher).

Miss Talib: In my classroom, I am Abu Zaid Al-Hilali. I know what I am doing. If I did not control the class in this way, then I would not have finished the chapter today. I swear if I give them a chance, the class will be a mess; then I would not be able to teach (fieldnotes, March 11).

Earler in Chapter IV, Miss Talib was seen in control of both the academic knowledge and the social order of the classroom. Time was also seen as a critical factor in justifying this control in order to cover the large amount of material in the limited amount of time available. Time factor did not only influence how the material was presented, but also how social interaction in the classroom was conducted.

Miss Talib has been using the textbook as an authority of knowledge. She stuck closely to its materials, assigning certain numbers of pages to be presented in each lesson, using the same sequence and almost the same language in her presentation (but in a colloquial spoken Arabic instead of the standard written one), emphasizing the terminology and definitions, talking about the practical activities and experiments in the same manner as she dealt with other "theoretical topics" instead of doing these activities, and ignoring the suggestions of the teachers' guide.

During the translation process of the standard Arabic of the textbook into her spoken colloquial Arabic, Miss Talib sometimes added more examples and drew figures on the board in order to clarify the idea she was teaching. But in this process she encountered some problems in modifying the original meaning or missing the whole point.

The number of textbook pages she assigned to cover during a certain lesson regulated the time which she decided to spend on those pages and prevented the time from being wasted. At the end of lesson 2-9, Miss Talib assigned the task of presenting colloidal solution in the classroom to Jamila, but she seemed prepared to start this presentation herself in the next lesson. A student noticed that and asked, "Isn't Jamila supposed to present the lesson today?" Miss Talib responded, "No, she will take more time; I need to finish the chapter in this lesson and start answering the chapter questions."

Miss Talib was asked by the researcher to chose from a list of teaching methods one which best described her teaching method in the tenth grade classroom. She chose the lecture and said that her usage of lecture is different from that used in college because she involves her students in question/answer interaction during a lecture. She justified her choice of lecture as being the best way to transfer more information to students than any other method during a given period of time; it is also the best way to maintain a direct control over students as they pay close attention to the teacher.

The question/answer activity which Miss Talib used was also another feature of classroom control. Most of the questions she asked required a choral response from students to give the teacher a feeling that they "follow" her in stating the correct information. She might answer the question herself, then ask the class to repeat the correct answer after her. Sometimes choral response was required just to keep students' attention from being distracted when the teacher was busy writing or drawing something on the board.

> When I state a definition and I need to write it on the board, they will repeat after me. there is no way for a mistake here because the right answer is mentioned and they are only required to repeat it. I am satisfied in this case. There is a role here to be performed. It is an indication that they are with me; they follow me in the subject instead of spending the time talking to each other when I am writing

> the definition on the board. They are with me in this case. They participate (third interview with Miss Talib, March 11).

Borrowing Olson's (1983) metaphor, Miss Talib seems like a mountain guide trying to maintain the attention of her students and not wasting time:

> Someone who knew the way to the summit and would not fall. Such guide adopts direct methods and is in close contact with those who follow. The relationship between the mountain guide and the climbers simply do not involve low influence climbing methods; they are hazardous, for one thing, and time consuming.

Miss Talib realized that such "complete control limits the freedom of students" and "lecturing is boring." Also, the choral response is sometimes a "source of confusion," but she emphasized that such practices were necessary because "teaching, after all, is giving information, and I am responsible for setting the conditions in which students can understand this information within the available time."

The control which Miss Talib was after made it difficult for students to initiate questions or make comments which might lead to extended discusisons. Although some bright students did, in a few cases, initiate questions and express different understandings from the teacher, the way in which the teacher dealt with such cases (not giving careful examination to the issue and hustling to judge the student's point as an incorrect one) discouraged other students from trying that technique. It was also noticed that whenever a discussion occurred between the teacher and a student, many students withdrew their attention as if it were not their concern. In this case, the teacher had to call on those students to pay attention, then she cut the discussion short. Therefore, discussion did not seem to be welcomed by Miss Talib.

A laboratory lesson also presented special problems to Miss Talib. Student attention was distracted by "looking and playing with things they see" as the teacher was explaining something. Students might be "in another valley; they might mess around, break some equipment . . . . some experiments are difficult to work . . . during my attempt to fix an experiment who will control the class?" This was apparent in lesson 3-3 which was given in the lab. As Miss Talib finished her usual presentation and turned to the equipment to start the experiment, students started talking, and she said, "Stop talking. Those who are making a colony there in the back. Rana, Nadia . . . "

In brief Miss Talib was proud of being like Abu Zaid Al-Hilali in controlling the classroom and exerting high levels of influence to maintain students' attention and invest the available time properly. It gave her a sense of accomplishment that something had been done. She felt the progress in moving in a systematic manner through the pages of the textbook. At the end of the lesson, she might ask the students to open their textbooks and show them this accomplishment, "Today we have covered topic x from page y to page z; prepare for the next lesson, topic x' from page y' to page z'."

That is her teaching craft. As far as students' learning is concerned, it is their own craft. Miss Talib expects them to understand the material after it has been presented to them. The final few seconds of the lesson are spent in giving students a chance to testify that they have understood and there were no questions to ask:

T: Is this clear?
Ss: Yes, miss.
T: Is that understood?
Ss: Yes, miss.
T: Any questions?
Ss: No response.

Some of the factors which contributed to the high level of control that Miss Talib practiced were mentioned earlier in various places, factors related to the constraints under which she found herself, with large sized classes, a heavy teaching load, grading papers and exams, preparing for teaching, low pay, declining social position of the teaching profession, etc. But some additional comments on the reason for this phenomenon might add to our understanding of it.

Three of the five professors of teacher education who viewed one of Miss Talib's lessons independently noticed the high level of her control over the classroom. They interpreted this by referring to the teacher's old memories about her school teachers and to the failure of college education to give the prospective teacher a better alternative. One of them put it this way:

> This is the way teachers have been taught when they were students in school, and this is also they way they were taught at college. It is not surprising that teachers exercise high levels of control and authority in their classrooms because we failed to show them another model. We tell them in our methods courses to give students more role and more share in classroom activities, we tell them about the virtue of the discussion method and inquiry method and all the items in the list of beautiful prescriptions, but we have never been able to teach them in a discussion method or in an inquiry method. When we examine them in methods courses, they write excellent answers about the importance of students' role and about better ways of conducting a classroom discussion, but when they teach they use what was more familiar to them in their schools and colleges, methods they are accustomed to (from an interview with Dr. Hasim, March 4).

Olson (1983 referred to a similar conclusion when he described his experience with teachers in England and in Canada:

> Teachers are aware that science education theorists and modern science curriculum projects often expect them to use methods which involve high pupil influence. Yet the methods espoused by such projects are rejected by teachers or, more importantly, teachers do not appear to construe these approaches effectively, and thus important parts of innovative doctrines are not implemented. Teachers persist in using more familiar, better understood practices like the syllabus system and recitation that I mentioned above, methods in which their influence remains high (p. 142).

Many administrative practices seemed to encourage teachers' control. Teachers' control was linked to strong personality, self confidence, and good teaching as was seen in the criteria for describing Miss Talib as a good teacher by the science supervisor and the school principal. Problem students are more likely to avoid confrontation when the teacher has such control. Those teachers are more likely able to cover the syllabus and put more pressure on students to study and perform well in exams.

Discussion of the Research Design

Ordinary people have a natural power to experience and understand (Stake, 1978). Case studies have the advantage of developing further understanding of some people (the readers) by building on the direct experiences of other people (case study researchers). When understanding and expanding the experience of a particular situation constitute the major aims of the research work, case study is a useful strategy.

In this case study, the purpose was not to produce generalizations in a way similar to that known in the process of scientific induction. The purpose was to set a basis for what Stake called "naturalistic generalization" which is "arrived at by recognizing the similarities of objects and issues in and out of context and by sensing the natural covariation of happenings." The need in this case was for

> . . . generalization about a particular case or to a similar case rather than generalization to a population of cases. The demands for typicality and representativeness yield to needs for assurance that the target case is properly described. As readers recognize essential similarities to cases of interest to them, they establish the basis for naturalistic generalization (Stake, 1978, p. 7).

This assurance of maintaining a proper degree of accuracy in describing what was supposed to be described in the case study is called the validity in research terminology. Validity in this particular case study in the recording of observations and descriptions was achieved through the relatively long term stay in a classroom, combining direct observation with repeated listening and/or viewing sessions of tapes, effectively serving the researcher to distinguish valid descriptions from invalid ones and supporting this validity by some contextual evidences. Checking the perspectives of the researcher with those of other participants was also another way of obtaining this validation.

Choosing the case study strategy served in focusing the attention of research on understanding the role of individual participants and their particular realities in that particular cultural milieu. During the period of the study, the researcher was concerned with the study of teaching and learning behaviors from the perpectives of the teacher, the students, and the principal--as insiders whose meanings, interpretations, and values are the most relevant factors in comprehending what actually happens within the classroom system. The rationale for considering this "emic"* dimension of perspectives was embedded in the purpose of the study--the holistic understanding of the teaching/learning process. The knowledge about their inner states of those people participating in this process was considered an essential factor for this understanding.

The "etic" perspective as contrasted to the emic refers to employing a perspective relevant to the interpretation of people from outside the research setting. It includes also the assumptions underlying the standardized quantitative systems of observation such as Flanders' Interaction Analysis Categories (FIAC). The FIAC system has been designed and used extensively in many studies to trace the types of teacher influence in the classroom by quantitative inspection of the amount of teacher talk and student talk and silence, then to describe teachers on a direct versus nondirect behavior continuum.

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*"Emic" and "etic" were first introduced by Pike (1967) as two approaches for describing language and culture where the "etic viewpoint studies behavior as from outside a particular system and as an essential initial approach to an alien system. The emic viewpoint results from studying behavior as from inside the system" (p. 37). Pike derived the words etic and emic from the words phonetic and phonemic to refer to a similar linguistic usage of the terms, but for more general purposes.

Flanders' system was used in this study partially not to make a judgment about the type of influence Miss Talib had. It served as an entry framework which allowed the researcher to organize his observation of the classroom behavior during the study and to categorize the verbal communication of the classroom as a base for further qualitative investigation during the data analysis phase.

The combination of quantitative data derived from the FIAC system and qualitative data derived from various ethnographic techniques proved to be effective to apply whenever any type of them may be useful. Using students' responses on various tests was also an example of combining quantitative data about students' learning and qualitative data generated through direct observation of students in the classroom and through students' responses to the researcher's questins during interviews.

The significance of using the case study strategy in this study was seen in its success of enabling the participants to play a major role in determining the boundaries of the study. The research in this case touched more directly the concerns of those insiders (the emic dimension) and data collectin and analysis had addressed these concerns.

One of the guiding ideas which the researcher carried with him to the research site was the idea of task analysis of the three components of the study: curriculum materials, actual classroom instruction, and students' learning outcomes. The researcher planned to share with the teacher the knowledge related to this analysis after she finished teaching the first chapter of the textbook. Miss Talib was not interested in this kind of analysis; she did not show any willingness to spend time doing it or in changing her style of planning method to incorporate the task analysis of chapter two to see how this idea might work.

Consequently, the phase of intervention which was originally planned was dropped from the study.

The researcher was careful not to identify his role with the role of any particular group in the system; otherwise, the way in which various participants might have seen him could have been influenced adversely. For the teacher, the researcher was not playing the role of a supervisor or a principal; for the students, he was not an eye for the teacher; and for the principal, he was not an official administrator from the Office of Education. In this way, he was able to maintain a spirit of trust which encouraged participants to share with him their intimate thoughts. Without this spirit, many insights, perspectives, and feelings would not have been conveyed to the researcher by those native participants. The atmosphere of frankness and trust which has been created is very difficult to achieve in other methodologies. An important factor contributing to this was embedded in the fact that the researcher did not intend to study that particular situation using a certain theoretical framework to make some evaluative judgments. Rather the research employed Wilson's (1977) advise to the ethnographer, to make himself a "sensitive research instrument by transcending his own perspective and becoming acquainted with the perspectives of those he is studying" (p. 261).

In brief, the case study strategy was an appropriate one for the purpose of this research: understanding the teaching-learning process of chemistry in a tenth grade classroom. The combination of qualitative and quantitative data was found helpful in providing two types of evidence to support assertions made in describing various aspects of the study. Ethnographic techniques provided triangulating evidence coming from perspectives of various people who are related to the field of the study and to get into the depth of that field. A major problem with using ethnography in this study, however, was the need for extended periods of time to conduct interviews with the participants. Had this time been available to interview the teacher and conduct sessions for viewing videotapes of her lessons, for example, more evidence to support the claims made by the researcher may have been produced.

CHAPTER VI

CONCLUSIONS, IMPLICATIONS, AND LIMITATIONS

Conclusions

The structure and objectives of the unit "properties of matter and the particle model" were similar to those of the first part of CHEMS. The quantity of subject matter of this unit was found to be too much to cover in the prescribed time. Miss Talib felt obliged to cover this amount. In order to do that, she omitted the experiments and practical activities to save time. She also realized that this rapid coverage would leave some students unable to understand the material.

The teachers' guide was not useful for Miss Talib because it did not contain material which could add to her own experience. Had the teachers' guide been written with specific suggestions about ways of presentation of topics, examples of relating particular concepts and topics to general themes or major conclusions, it could have been more meaningful to Miss Talib's own situation.

The textbook was used as the only source of knowledge and was found useful, especially the printing of main concepts, definitions, and conclusions in blue and the use of margin notes on some pages to summarize certain conclusions and definitions.

The questions and problems at the ends of chapters were viewed as important. All those questions and problems were answered in the classroom in lessons devoted to this purpose. Although these questions were answered in the teachers' guide, Miss Talib encountered some difficulty in dealing with them.

Most of her difficulties were related to numerical problems regarding the laws of chemical composition or to vapor pressure.

The curriculum materials seem to have failed in conveying the intentions of the curriculum developers to the teacher; they did not provide direct linkages between the specifics of the subject matter and the general principles. The teacher was not able to provide these linkages in her classroom teaching. Although many students learned most of the specifics, they did not learn the general themes of the curriculum.

Teaching and learning in Miss Talib's classroom were mainly limited to conceptual knowledge of the course. Objectives related to the nature of science and the work of scientists and to the development of scientific attitudes and skills were not addressed in the classroom because they were not considered part of the conceptual knowledge. The low level of understanding the nature of science, excluding practical activities and ignoring attitude and skill objectives, were not unique to Miss Talib's classroom. Evidence was presented that shows that this classroom is representative of many other classrooms in this respect. Topics in the textbook were all presented in the same sequence: lecture method combined with questions and answers at the recall level. The problem that Miss Talib faced in teaching some topics in the program were due in part to the confusing method of presentation of those topics in the program materials; but in some cases, the teacher missed the meaning of what she read in the textbook and assigned other meanings derived from her own experience in other sources.

Time was a major factor in understanding many aspects of teaching and learning in Miss Talib's classroom. Writing a lesson plan was viewed by her as a waste of time; conducting experiments needed part of her personal time which she did not want to give away. She believed that all students could understand all the material provided she could spend the time required to meet the needs of various types of students and provided that the prerequisite knowledge was available.

Miss Talib practiced a high level of control over the knowledge and social order in her classroom. She was aware of the disadvantages of such control, but she beleived that it was necessary to set conditions in which she could cover the required material within the available time frame. Such control was viewed also as an important factor in describing a good teacher who has a strong personality and does not allow for wasting time.

Students in Miss Talib's classroom did not have an active role in negotiating aspects of classroom activities, because they were not granted that choice. Even raising questions about what they did not understand was not a common practice, because they were afraid to do so. They admitted that the teacher did not mind being asked questions, but they did not appreciate the way she dealt with those questions. Although students praised the teacher for her sincerity and commmitment in spending lesson time teaching subject matter, some students mentioned that they had problems answering questions about topics they thought they understood well.

Understanding the nature of science was considered a fundamental goal of the natural science course. However, most students did not achieve that goal. Most students had problems learning certain topics such as the laws of chemical compositions, Faraday's laws of electrolysis, concentration and molarity of solutions, and the relationship between vapor pressur and boiling point. In most cases, the teacher herself had problems understanding these topics. The confusion which the teacher encountered in her teaching might account for the students' poor level of learning as measured by tests and observed in classroom communication.

Generally speaking, many students showed considerable progress in learning from instruction as measured by the difference between their performance on pretests and posttests. There were cases where students learned from the textbook and were not confused by the errors the teacher made in her teaching. The poor level of learning the general themes and principles was interpreted to mean that neither the curriculum materails nor the classroom instruction provided direct emphasis on these themes and principles; instead, the emphasis was on the specifics of subject matter without relating that to the general principles and main ideas.

In her teaching Miss Talib tried to transfer subject matter knowledge from the textbook to her students. She expected students to master that knowledge just as she passed it on to them. The academic meanings of that knowledge were the teacher's own property, and her responsibility was to share that property with her students. Since classroom teaching was limited to conceptual knowledge, students did not have a chance to learn the intended skills or develop the intended attitudes related to the experimental aspect of the subject matter.

The perceptions students could develop from reading the textbook at home should be suspended until the teacher presented the topic, at which time she assigned her own interpretations. During the presentation, the teacher initiated questions and evaluated student responses according to those meanings.

The teaching and learning process was carried out by the teacher's attempt to move students into her system of meanings. Miss Talib provided various clues to assure the success of this movement. At the end of each segment of teaching, she asked, "Did you understand what I mean? Is that clear? Do you have any questions? If you did not understand, I will repeat."

As the teacher was teaching a topic, she was trying to tell students the meaning of the content of a topic; and by this process of telling, students were expected to understand the meaning. That was how students were expected to learn. Despite these continuous efforts on the part of the teacher, many students did not learn; they did not succeed in adapting Miss Talib's system.

In cases where Miss Talib had assigned different meanings than the students developed through their reading of the textbook, some students dropped their own meanings to adopt the teacher's meaning without having a clear understanding where the meanings came from. Few students continued to hold their own meanings because they thought that the "teacher was talking about something else."

This study was a case study of one teacher in one classroom. Miss Talib was chosen as a good teacher on the assumption that a good teacher would be a good choice for the study. However, the analysis of this case through interviews with the school principal, science supervisors, students, and several teacher educators revealed that Miss Talib was not a special case. Whether in her approach to classroom instruction, in using curriculum materials, in the way she dealt with students, or in her attitudes toward doing experiments and writing lesson plans, Miss Talib was a reasonably typical example of science teachers in Jordan, although she may have had a better scientific background than many.

The initial questionnaire sent to 18 teachers of the NSC for tenth grade revealed that Miss Talib was among the majority who did not use the teachers' guide. Ten other teachers in various schools in the same city as Miss Talib responded to questions about the way they dealt with the experimental part of the curriculum by revealing results similar to those observed in Miss Talib's classroom. In addition, when some students were asked about the impact of the way Miss Talib had reprimanded students, they indicated that they got accustomed to this. One student said "most teachers insult students." The school principal praised Miss Talib for her sincerity and commitment, but she admitted that Miss Talib was among the majority of teachers who viewed lesson planning and the experimental part of the curriculum negatively. Similarly, the teacher educators who viewed a tape of Miss Talib's lesson observed that the case was very familiar to them in terms of her high level of classroom control and her use of a great deal of telling and recitation practices.

The description of this particular case of a science classroom in Jordan was similar in many aspects to many cases described in literature of science classrooms in other countries, especially in those cases described by Olson (1983) in Canada and the United Kingdom and those cases referred to by NSF case studies in the United States (Stake & Easley, 1978).

The typicality of Miss Talib's case adds to the significance of this study and makes the implications of this study relevant to many other cases.

Implications of the Study

The development of various techniques by which teachers can self-monitor the effects of their own teaching behaviors in the classroom in order to improve their practices and their students' learning is the most important purpose of doing research from this type. Teachers who read reports of research of this type can reflect on their own situation and develop a tendency to focus on the meanings of their classroom instruction. In addition to the improvement of claassroom practice, there are other aspects of implication which are summarized in the following paragraphs.

Implications for Curriculum Development

Teachers have been using the Natural Science Course as well as other chemistry courses in classroom in Jordan for 10 years. There was no pilot draft or try out experience when textbooks were approved. Curriculum development literature refers to the importance of trying out the curriculum material before publishing the first edition. This study indicated that teachers and supervisors have many problems with the NSC. Classroom teaching and learning were found to be far below the expectation of curriculum developers in terms of the way science was presented in the classroom and in terms of the low level of students' learning in various domains of instructional objectives.

Chemistry as experimental science and the processes of scientific inquiry should not just be slogans for making innovations. Real innovations occur only when classrooms employ them. In the same vein, data from this study imply that the continuous process of evaluating the curriculum material is needed in Jordan. The reports that many teachers, principals, and science supervisors have written about the problem they encountered in curriculum materials should be treated seriously by the Ministry of Education. Whatever the experience of curriculum developers, the experience of teachers and students in the classroom with the products of curriculum development is what really counts. Improving curriculum materials should always be a continuous endeavor.

Implications for Further Research

The research reported in this study has left the researcher with more questions to ask and more points to pay attention to, rather than less. This comes as no surprise. The teaching/learning process in the classroom is so complex and the variables and factors which influence this process are so many that, when this fact is added to the continuous change in the conditions of our social life, our schools and our knowledge and techniques, research should be a continous process of inquiry to provide ways for better understanding what happens in the classroom.

There are aspects which this study has shown a need to research and study. The following areas are among them.

1. Curriclum of chemistry in Jordan has been developed following the line of the American CHEMS. The goals and objectives are almost the same. The experiments and practical activities are also similar. The nature of chemistry as a science conveyed in both curricula is not expected to be different. But people in Jordan and the United States, although sharing some values and beliefs, differ in many world views and other values and beliefs which might influence their ways of thinking and understanding science. The consequences of cultural borrowing, in the case of adapting American chemistry courses as well as other science courses, constitute an interesting subject for resarch. The subject might be best studied in a similar case study. The strengths of the interview, which lie in its ability to elicit personal opinions, understandings, and values, should be given more space in such a study in order to trace the origins of philosophical commitments of the interviewees and to understand how these commitments are treated in the teaching/learning process.
2. This study built an adequate base for many other case studies which can focus on a smaller portion of the subject matter, where students' learning may be investigated in depth and be

related to (a) corresponding segments of the classroom instruction, (b) the presentation of the topic in the curriculum material, and (c) student knowledge prior to instruction.

3. Some teachers like Miss Talib do not feel the need for help from the teachers' guide or other sources, partly because they did not have this kind of help before. It is expected that a more useful revision of the teachers' guide might challenge those teachers and encourage them to improve their performance. A study such as the one reported here can be considered a pilot study for another one which includes an intervention phase where the problems identified in curriculum materials in the study can be treated and a revised edition may be developed and used in the proposed study to get a better understanding how curriculum materials are used.

4. Teachers who have negative attitudes toward planning and doing experiments can change this attitude by participating in case studies where planning and doing experiments are the focus ofthe study. Teachers who are used to certain ideas resist changing them. But when circumstances convince them to change, they might find new approaches which are more effective in improving students' learning and their own effectiveness. This could result in better job satisfaction for the teachers.

Implications for
Preservice Teacher Education

One videotape of a lesson taught by Miss Talib was independently viewed by five university professors and two science supervisors. After these viewing sessions, the discussion of the researcher with those science and teacher educators pointed out bitterness toward and dissatisfaction with the status of science education in Jordan. They referred to the fact that teachers teach science by telling and dictating the information presented in the textbook (in many cases, explaining it incorrectly), while the investigative spirit is completely excluded from the curriculum. One of the reasons given for this situation by those science and teacher educators was the status of the university education which represents the preservice education of teachers. They referred to the separation of knowledge from its pedagogy. Knowledge of subject matter which is usually addressed at the school level is not addressed at the university level. Experiments are done by using advanced equipment which is not available in school labs. Knoweldge of education and methodology is provided through certain courses which are given in a fragmented way, dealing with theoretical situations or situations described in textbooks which are written for readers of other societies.

In the present study Miss Talib stated in several instances that her university preparation was not of great help to her, even in her graduate courses in the diploma program. She was not interested in pursuing the master's program because she did not expect it to provide her with any new experience.

Preservice teacher education should be reconsidered carefully to provide teachers with real life experiences which help them meet the challenges they expect to face in the classroom, whether related to an understanding of the subject matter they will teach or to the methods of presenting this subject or the techniques of promoting their students' learning.

Implications for Inservice Teacher Education

It has been documented in educational circles in Jordan that many teachers hold negative attitudes for educational supervision, partly because of the old position supervisors used to hold as inspectors (the previous name of supervisors) and partly because an important purpose of the supervisor's visit to schools is to evaluation teachers' performance.

Whatever their preservice training might be, teachers continued to be in need of help from someone with more experience. Science supervisors can provide important help if they obtain the trust of those teachers. A supervisor who is responsible for visiting a large number of teachers every year in addition to performing other adminstrative and technical responsibilities might not be able to obtain the needed level of trust. A better situation may be seen in the light of this study, where building the mutual trust between the science supervisor and science teacher is considered essential. If each science supervisor were assigned a certain number of teachers (say 20 or 30), then s/he could meet with them often, in weekly or bi-weekly seminars, in school and classroom visits designed for certain professional purposes, discussing the specifics of subject matter, teaching behavior, and student learning. In this way, science supervisors could act as bridges to exchange many experiences among various teachers. Providing some incentives for teachers' professional development seems essential in this case.

Limitation of the Findings of This Study

The limitations related to the implication of the finding of this study should be realized from the fact that it is a case study which involved one teacher in one classroom who was observed during a period of seven weeks while teaching part of a chemistry unit. Careful consideration should be given to any implication beyond teaching this instructionnal material in that particular classroom by that particular teacher. The purpose of the study, however, was not to generalize from it the statistical meaning of generalization. Naturalistic generalization, however, can be established as was examined in the discussion of the research method.

There were several circumstances which limited the ability of the researcher to get into the depth of some aspect of the situation he was studying. The cultural commitments related to sex separation allowed the researcher to spend only short periods of time in interviewing participants of a girls' school.

The attempt of the researcher to avoid engaging in delicate situations where the trust of the participants might be endangered was a source of limitation for the study, especially in areas where data about how participants viewed each other were important.

The analysis of data during the period of observation was very helpful in developing the hypotheses and testing them continuously. The rest of the analysis had been done with no way to continue this kind of interaction with participants. Had the teacher, for example, been available for more viewing sessions to reflect on her behaviors which were the subject of analysis, she could have added more richness and depth to the analysis.

Ethnography, although, was a powerful methodology for providing a rich description and understanding. It represented, however, some source of limitation, especially by putting the emphasis on a wide scope rather than dealing with the specifics. This dissertation was considered a summary of what could be found in the case study. The large amount of data can yield much more analysis and findings than what has been reported in this dissertation.

APPENDIX A

CONTENT OF NATURAL SCIENCE COURSE

CONTENT OF NSC VOLUME I

UNIT ONE

MEASUREMENT, EXPERIMENTATION, PREDICTION AND EXPLANATION

Chapter One: Scientific Measurement

1.1 Definition of scientific measurement
1.2 Characteristic of scientific measurement
1.3 Measuring time
1.4 Measuring distance
1.5 Measuring mass
1.6 Measuring velocity
1.7 Units of measurement

Chapter Two: Scientific Experimentation

2.1 Scientific observation
2.2 Making experiments: example of melting point of a pure substance
2.3 Dissemination of results of experiments

Chapter Three: Prediction and Explanation

3.1 Scientific prediction
3.2 Scientific explanation
3.3 Prediction of earth structure
3.4 Prediction of the stars
3.5 Prediction of planets

UNIT TWO

Chapter Four: The Concept of Equilibrium

4.1 The concept of equilibrium
4.2 System and state of a system

Chapter Five: Equilibrium of a Solid Under Forces

5.1 Newton's Laws
5.2 Force measurement and bodies weight
5.3 Forces and equilibrium of bodies

Chapter Six: Pressure

6.1 Definition measurement and units of pressure
6.2 Pressure in liquids

Chapter Seven: Equilibrium of a Solid in Liquid

7.1 Equilibrium of a solid in stationary liquid
7.2 Equilibrium of a solid in moving liquid

Chapter Eight: Equilibrium in Gas Systems

8.1 Gaseous state
8.2 Relationship between pressure and volume of gas
8.3 Relationship between volume and temperature of gas

Chapter Nine: The Atmosphere

9.1 Nature of atmosphere
9.2 Strata of atmosphere
9.3 Measuring atmosphere

Chapter Ten: Heat Equilibrium

10.1 Measuring temperature
10.2 Heat quantity
10.3 Heat mixtures
10.4 Change of state and potential heat
10.5 Heat transfer

Chapter Eleven: Equilibrium in Hydrosphere

11.1 Introduction
11.2 Structure of hydrosphere
11.3 Properties of hydrosphere

Chapter Twelve: Hydrolic Equilibrium in the Atmosphere

12.1 Introduction
12.2 Saturation and condensation
12.3 Relative humidity
12.4 Saturation and condensation near earth surface
12.5 Saturation and condensation in high strata of atmosphere
12.6 Clouds and thunderstorms

Chapter Thirteen: Equilibrium in the Movement in the Atmosphere

13.1 Pressure gradient force
13.2 Coriolis force
13.3 Geostrophic winds
13.4 Surface winds
13.5 Classifying surface winds
13.6 Winds in high strata of atmosphere

CONTENT OF NSC VOLUME 2

UNIT THREE

PROPERTIES OF MATTER AND PARTICLE THEORY

Introduction

Chapter One: Building the Atomic Model

1.1 Gas laws as source of knowledge about the structure of matter
1.2 Laws of chemical composition as source of knowledge about the structure of matter
1.3 Masses of molecules and Avogadro's hypothesis
1.4 Number of atoms in a gas molecule
1.5 Masses of atoms and molecules
1.6 The mole: Avogadro's number
1.7 The atom and molecule--the element and compound
1.8 Building a molecular model of a gas--real gas and ideal gas

Chapter Two: Pure Substance and Solution

2.1 Properties of pure substance
2.2 Distinguishing solution from pure substance
2.3 Properties of solutions
2.4 Concentration of solutions
2.5 Solubility
2.6 Solutions of electrolytes and non-electrolytes
2.7 Separation of components of solutions
2.8 Colloidal solutions

Chapter Three: Expanding the Atomic Model

3.1 Electrical nature of a matter
3.2 Experiments of electrolysis of solutions
3.3 Experiments of discharge tubes
3.4 Rutherford's experiments
3.5 The nucleus of the atom
3.6 The mass and volume of an atom
3.7 The forces inside an atom
3.8 The forces between atoms (chemical bonds)
3.9 Some properties of matter explained by the atomic model
3.10 Attraction forces between molecules: states of matter

Chapter Four: Chemical Reaction

4.1 The meaning of chemical reaction
4.2 Chemical equation
4.3 Writing chemical equations
4.4 Stiochiometry
4.5 Energy changes in chemical reaction

Chapter Five: The Periodicity of Properties of Elements

5.1 The need for the classification of elements
5.2 Inert gas: the simplest group of elements
5.3 Alkali metals
5.4 Halogens
5.5 Hydrogen
5.6 Elements of the third period
5.7 The development of periodic table and its structure

UNIT FOUR

ENERGY

Chapter Six: Work, Energy and Power

6.1 Work
6.2 Power
6.3 Energy
6.4 Energy conservation
6.5 Momentum
6.6 Impulse
6.7 Momentum conservation
6.8 Elastic and inelastic collision

Chapter Seven: Energy Sources

7.1 Sources of energy in the world
7.2 Solar energy
7.3 Fuel energy
7.4 Nuclear energy

Chapter Eight: Energy Forms and Transformation

8.1 Mechanical energy to electrical energy and vice versa
8.2 Heat energy to electrical energy and vice versa
8.3 Light energy to electrical energy and vice versa
8.4 Chemical energy to electrical energy and vice versa
8.5 Mechanical energy to heat energy and vice versa

Chapter Nine: Energy Transfer

9.1 Energy transfer by current
9.2 Energy transfer by waves
9.3 Energy transfer by field

Chapter Ten: Energy Exchange Between the Atmosphere and Earth Crest

10.1 The formation of earth surface
10.2 Denudation
10.3 Sedimentation

Chapter Eleven: Energy Exchange Between Atmosphere and Hydrosphere

11.1 Heat energy exhcange bewteen atmosphere and hydrosphere
11.2 Kenetic energy exchange between atmosphere and hydrosphere

APPENDIX B

CONTENT OF UNIT THREE

CONTENT OF UNIT THREE

UNIT THREE

Chapter One: Building Atomic Model

Preface

1.1 Gas laws as a source of knowledge on the structure of matter
1.1.1 Some properties of gases
Activity one: Colors of gases
Activity two: Solubility of gases in water
Activity three: Chemical indicators colors in gases
Activity four: Chemical reactions in gases
1.1.2 What are molecules of a gas composed of?
1.2 Laws of chemical composition as a source of knowledge about the structure of matter
1.2.1 The law of conservation of matter
1.2.2 The law of definite proportion
1.2.3 The law of simple multiple proportions
1.2.4 The law of reciprocal proportions
1.2.5 Explaining laws of chemical composition by Dalton's theory
1.2.6 Law of reacting volumes of gas
1.3 Avogadro's hypothesis and masses of molecules
1.4 Number of atoms in a gas molecule
1.5 Masses of atoms and molecules
1.6 The mole--Avogadro's number
1.7 The atom and molecule--the element and compound
1.8 Building a molecular model of gas--real gas and ideal gas

Chapter Two: Pure Substance and Solution

2.1 Properties of pure substance
2.1.1 Change of solid into liquid--melting
2.1.2 Change of liquid into gas--evaporation and boiling
2.1.3 Vapor pressure--equilibrium between liquid and its vapor
2.2 Distinguishing a solutin from pure liquid
2.3 Properties of solutions
2.3.1 Behavior of the solution during heating
2.3.2 Behavior of the solution during cooling
2.4 Representation of solution concentration
2.5 Solubility
2.5.1 Solubility as a measure of saturated solution concentration
2.5.2 Factors affecting solubility
2.5.3 Super-saturation phenomenon
2.6 Solutions of electrolytes and non-electrolytes
2.6.1 Practical activities
2.7 Separation of the component of solution
2.7.1 Distillation
2.7.2 Crystallization

2.7.3 Extraction
2.7.4 Factional distillation
2.7.5 Fractional distillation of liquid air
2.8 Colloidal solution
2.8.1 Practical activities

Chapter question

Chapter Three: Expanding of Atomic Model

Preface

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3.2 Experiments of electrolysis of solutions
3.3 Experiments of discharge tubes
3.3.1 Positive charges and the discovery of the proton
3.3.2 Thompson's model of the atom
3.4 Rutherford's experiment
3.5 The nucleus of atom
3.6 The mass and volume of an atom
3.7 Forces inside atoms
3.8 Forces between atoms
3.8.1 Metallic bond
3.8.2 Ionic bond
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3.9 Explaining some properties of matter by the atomic model
3.9.1 Electrical charge and electrical conductivity
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3.10 Attraction forces between molecules: change of states
3.10.1 The difference of attraction forces in the three state of matter
3.10.2 Intermolecular forces. VanDerWall's forces
3.10.3 Molecular ploarization and the hydrogen bond
3.10.4 Attraction forces in ionic crystals

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4.2 Chemical equations
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4.3.2 Indentification of reactants and products
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5.2.2 Sodium chloride--achieving the state of inert gas
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5.4 Halogens
5.4.1 Some properties of halogens
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5.4.3 Halids of other elements
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5.5.1 Some properties of hydrogen
5.5.2 Reaction of hydrogen with sodium
5.5.3 Reaction of hydrogen with chlorine
5.6 Element of the the third period
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5.6.2 Some compounds of the third period elements
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Chapter questions

APPENDIX C

AN EXAMPLE OF FIELD NOTES

FIELD NOTES

Lesson: 1-4
Date: February 2, 1982, Tuesday
The second period: 8:50-9:35

Number of students present: 58
Number of students absent: 2
Taghrid Hatamleh, Summaia Kawahli

The teacher and I entered the classroom at 8:51. I sat in the back of the second column of tables with the tape recorder beside me and the teacher held a wireless microphone. She felt uncomfortable putting it around her neck. Next time she would prefer to wear it on her coat. The chalkboard is clean except for the title of the new lesson: The law of equal volumes" on the middle of the board, and the date on the upper right corner. The teacher alerted me to turn on the recorder and she began.

T: Close your book first (secondary) class. Give me your attention. We need to make a review. (After a few questions about the definition of the first two laws, she noticed a low response. None of the students raised their hand to defined the third law.)

T: "Why, class, are you lazy today? What is the matter? Are you still busy in the transfer from this school to the comprehensive school? No more transfers to the comprehensive school now. That is it. We are here now. You either study well or leave the school."

(Rana raised her hand and she was called on to give an example of the third law.

The teacher repeats almost each word Rana utters while she is solving the problem on the board. In the mixed choral responses, I can distinguish that the responses of many students are different from each other.)

Example:

T: Always, any two elements react with each other to produce more than one compound, the proportions are:

T + Ss: Multiple of each other. (More than one student around me said: simple numerical proportion, and at least two students said constant proportion.)

(It is obvious that the teacher did not explain the law of the simple multiple proportions effectively. She failed to state the conslusion correctly. When she asked a student to repeat the conclusion of the definition of the law. The statement of the student was a meaningless one. The teacher, however, built on it and ended it by an incorrect phrase; an example follows.)

T: So what is the definition of the law of simple multiple proportions?

Jamila: If an element reacted with a constant mass proportion and the proportion was not constant, than the proportion between the two masses is a simple numerical proportions.

T: A multiplied proportion.

(The definition in the text book is:

When two elements react with each other to form more than one compound, the proportion between the masses of one element which combine with a constant mass of the other element is a simple numerical proportion.)

(This definition is stated twice throw two different examples H_20/H_20_2 and CO/CO_2 and for a third time on the margin in blue color.)

(The review lasted for 15 minutes)

$HCL + NH_3 \quad NH_4CL$
(She counted the number if similar atoms in each side of the equation and found them equal. Then she asked,) "What is the law of chemical composition which I preserved in this case?"

(It was easy to distinguish among many attempts of the student random responses the following:

-----Law of definite composition
-----Law of definite composition
-----Law of simple multiple proportion
-----Law of conservation of mass

Some students around me tried more than one law.)

"Of course, Avogadro's hypothesis is not obsolutely true, they adopted it because they did not find a better one". Usually I tried to discover the better. Avogadro's hypothesis was able to explain the law of equal volumes."

(She mentioned that the temperature of the standard state is 20 degrees centigrade. That is incorrect. It is 0 degrees centigrade.)

T: What is the definition of the mole?

Ss: It is Avogadro's number.

T: It is Avogadro's number but what is its definition?

(Noises)
(No hands were raised)

T: Today the class is not with me at all.

(Noises)
(No hands)

T: Hurry up...you in the back

S: It is the mass of Avogadro's number of atoms

(Teacher nodded in agreement and repeated the same statement, accompanied by many other students.)

T + Ss: It is the mass of Avogadro's number of atoms...

(Teacher wrote this on the board.

Write on your notebook! (She dictated the following problem.)

"We have a mole of chairs. The mass of one chair is 3 grams. What is the mass of the mole of chairs?

(Relatively long period of wait time interrupted by direction and one instance of criticism. After some time, few students started to raise their hands. The teacher asked what about the others. She called on Wisal to solve the problem.)

Wisal: We multiply the 3 grams by the number of chairs.

T: (rejecting the response) First tell: how many chairs are available

Ss: Avogadro's number

T: (She wrote on the board while she said:) one mole of chairs has 6.02×10^{23}

What is this number?

Ss: Chairs

T: What is the mass of one chair?

Ss: 3 grams

T: The mass of all chairs?

Ss: Multiply by three

(During this time Wisal was standing up expected to respond to teacher's questions, but responses were given in chorus by many other students, too.)

(Definition of element, atom, molecule, compound, molecular formula, structural formula... She spent some time writing on the board.)

T. I represent the atoms by symbols which we will take next time. Prepare up to the end of the chapter. Answer the first five questions from chapter questions.)

APPENDIX D

TRANSCRIPT OF LESSON 2-3

BEHAVIOR OF THE SOLUTION AND MOLARITY

TRANSCRIPT OF LESSON 2-3, February 11

BEHAVIOR OF THE SOLUTION AND MOLARITY

(Before the teacher's arrival to the class, a student has written in the middle of the chalkboard: Natural Science. In the upper right corner the date: February 11, and below it, the topic of today: "Behavior of the Solution During Cooling". After setting the camera, the camera man was looking at the teacher to give a sign of start. She gave the sign by a clue of her head, then started).

002 T: Today we will continue the behavior of solutions

Ss: During cooling

T: During heating and cooling, we will go back to the boiling process. Yesterday we had the boiling point of a solutin as compared with the boiling point of a pure water. We used a solution of sugar in water and noticed two conclusions. What was the first conclusion? What was the first conclusion in relation to the boiling point? What was the conclusion?

(She moved forward in the isle and pointed to a nearby student without calling her name. No name is shorthanded NN)

S: No response

T: The boiling point of a solution in comparison with the boiling point of a pure water equal, more or less?

(Noises)

(Teacher pointed to the class to calm and wait)

Why did you not study?

(Talking to the student who could not answer)

You should have studied in order to be able to answer. Yes, Basma.

Basma: The boiling point of a solution is higher than the boiling point of a pure water.

(A lady from outside the classroom was seen opening the door. Miss Talib waved her hand to close the door, and that lady quickly closed the door. A student put a concrete block behind the door so that the wind would not blow it.)

T: Boiling point of a solution is higher than boiling point of a pure water.

(T. wrote the statement on the chalkboard the statement)

009 T + S: The boiling point....(while she was writing on the chalkboard)

T: What was the second conclusion? (Noises) Yes? (Pointing to a student NN)

S: The boiling point of a solution does not stay constant while it is boiling

T: (Repeated student answer and added)...because the proportion of sugar increases as water of the solution evaporizes. (She wrote on chalkboard: Boiling point did not stay constant.) So the temperature did not. . .

T + Ss: Stay constant

T: During

T + Ss: Boiling

T: It continued

T + Ss: Rising up

T: Now I will represent those results for both (she started drawing on chalkboard while she continued talking...)

T + Ss: the solution

T: And

T + Ss: Pure water

T: The kind of representation is

T + Ss: Graphic representation

T: I make two axis: X and

T + Ss: Y

T: X represents

T + Ss: Time

T: Time measured in

T + Ss: in minuted

T: Y represents

T + Ss: Temperature

T: Temperature measured in

T + Ss: Centigrade degrees

T: Suppose that the temperature of water (she wrote on the chalkboard 99 degrees centigrade)

T + Ss: 99 degrees centigrade

T: As I am heating the water what happens to the temperature?

T + Ss: Temperature increases.

T: Until it reaches (she drew the line AB and put 100 degrees centigrade)

T + Ss: 100 degrees centigrade

T: What happens at 100 degrees centigrade? Yes? (Pointing to a student NN)

S: Water starts boiling

T: So it starts changing form

T + Ss: Liquid state into gaseous states

020 T: Why are you talking together? (directing her statement to the whole class) When it boils what happens? Yes? (Pointing to a student NN)

S: It evaporates changing from

T + Ss: Liquid state into gaseous state

T: And the temperature (drawing the horizontal line BC in the graph)

T + Ss: Temperature starts rising up again

T: So here C-D is the gas and here (BC) It will change from liquid

T + Ss: Into gas

T: Now I want to compare this with the solutions I will draw the same thing for the

T + Ss: Solution

025 T: In case of the solution, what is the boiling point?

Ss: Higher

T + Ss: It is higher than the boiling point of pure water

T: Because vapor pressure of the solution is less than that of pure water. I assume that the temperature reached 101 degrees centigrade. (She drew the graph of solution pointing to the place of 101 degrees centigrade). The solution starts boiling

T + Ss: Changing from liquid to gas

T: What happens to the temperature? Afifa? Does it stay constant?

Afifa + Ss: No

T: Temperature did not stay constant. What happened?

T + Ss: It continued to rise up

T: Let us represent the temperature by (she drew a dashed line)

T + Ss: A dashed line

T: This graph is for what? (Writing on the graph solution and uttering the word solution...in a certain intunation as if the atatement should be completed

S: The pure (pure solution)

Ss: The solution

T: The solution which is made of more than one substance. This is the difference between the pure water

T + Ss: And the solution

T: Here (pointing to the graph of the soltuion) as you heat, the temperature rises up, at a certain temperature, the boiling occurs. What is the boiling point of the solution in comparison with the boiling pont of pure water (pointing to a student NN)

S: Higher

T: Higher than

T + Ss: The boiling point of pure water

T: Because its vapor pressure is less

T + Ss: Than vapor pressure of pure water

T: This is the case of heating. Now I will start studing the behavior of the solution

T + Ss: During cooling

T: The opposite process. Take pure water at 101 degrees centigrade. What happens when you cool it?

Ss: It loses heat

T: It loses heat, what happen? (pointing to a student NN)

S. It changes from gaseous state into liquid state

S: No miss

S: No miss

T: I am saying it is a liquid (pointing to another student NN)

S: It condenses

Ss: Noises. (Teacher pointed to the class to be quiet)

T: It is a liquid. When we cool it down what happens?

S: Temperature decreases

T: First temperature decreases, then it starts freezing at what temperature does liquid freeze?

S: At 0 degrees centigrade

T + Ss At 0 degrees centigrade

T: (writing on chalkboard and stating) the freezing point of pure

T + Ss: Water is 0 degrees

T: Now I will see the freezing point of the solution is it 0 degrees or less

T + Ss: Or higher

T: Take solution of sugar

T + Ss: in water

T: And start cooling, what will happen to the molecules? When I cool them down? Manal?

Manal: Their movement decreases

T: Their movement decreases, and the molecules become closer to each other. In a certain moment, the molecules become closer to each other. In a certain moment, the molecules start arranging and changing into

T + Ss: 0 degrees centigrade

T: Heat transfer from hot...

T + Ss: Object to cold object

T: Until the temperatures become equal. The water and sugar in the solution start freezing, molecules become closer until it changes into what?

Ss: Solid state

T: What do we call the temperature at which the solutions freezes?

(pointing at a student NN)

S: The freezing point

T + Ss: Freezing point

T We continue cooling down, when temperature is less than zero, the solution starts freezing, which one should I cool more, in order to freeze, the solution or pure water? (Silence) (Then very few hands are raised up). Which one do we freeze more, the solution or pure water? (pointing at a student NN)

S: The solution

T: The solution, so what did we notice about freezing point of the solution? What did we notice? (pointing at a student NN)

S: Freezing point of a solution is lower than freezing point of a pure water. (T. wrote on chalkboard: Water freezes at 0 degrees centigrade, solution freezes at lower than 0 degrees centigrade while she was stating it)

T + Ss: at less than 0 degrees centigrade

T: Try this in a refrigerator. Fill a container of water and another one of solution. After one hour you notice that water has frozen, but solution has not. So boiling point of a solution is

T + Ss: Less than boiling point of pure water

T: During the freezing notice the termometer, you find that temperature continues to decrease, that temperature

T + Ss: continues to decrease

064 T: The reason for that is that the water will freeze but the sugar will stay in the rest of the solution, causing more concentration in the solution and more decrease in temperature because cooling continues. (T. started cleaning the chalkboard in the middle part, the graph, while she continued talking. Than a student went out to complete cleaning chalkboard). Now we will represent the freezing of water and solution during cooling process. (T. used the two axes of the previous graph) Suppose that I start from water at 1 degree centigrade. Water will start decreasing in temperature from +1 degree centigrade into 0 degrees centigrade (she drew A-B). It's kinetic energy decreases until it reaches 0 degrees centigrade. What will happen at zero? Rahma? What will happen to the water? Rahma? (Noises)

Rahma: Water freezes

T + Ss: Water freezes

T: Water starts changing from...

T + Ss: Liquid to solid

070 T: Temperature will stay constant until...

T + Ss: All water changes into solid

T: What happens next? Yes (pointing to NN student)

S: Temperature continues to decrease

T + Ss: Temperature continues to decrease

T: This is the graph of pure water, the graph...

T + Ss: of pure water

T: The solution will cool, did it freeze at 0 degrees centigrade? Did the solution freeze at 0 degrees centigrade (she pointed at a NN student)?

S: No

T: No it has frozen below 0 degrees centigrade. Suppose it will reach this point less than 0 degrees centigrade, between 0 degrees centigrade and -1 degrees centigrade, less than 0 degrees centigrade, did temperature stay constant?

Ss: No

T: What happened

T + Ss: Temperature continued to decrease while solution is freezing

080 T: Next time all of you, write on your notebook: Explain why: <u>first</u>: freezing point of a solution less than that of pure water. <u>Second</u>: temperature did not stay constant while cooling a solution.

Next time I need this explanation on your notebook. Is there any question about solution, how it behaves during boiling and cooling and the difference of boiling point of pure water and solution and freezing point of pure water and solution?

(There was no response)

Clean the chalkboard. We will start the concentration of a solution (she wrote on chalkboard "Concentration of Solutions"). Let us go back to the cup of sugar and water. Two identical cups. In the first we disolved one spoon of sugar and in the second, we dissolved two spoons of sugar. Which of them is sweeter? Yes? (pointing at a student NN)

S: One with more sugar

T: Why two spoons of sugar in a cup of water is sweeter than one spoon of sugar in a cup of the same size? (looking at the same student)

S: (same student) Because molecules of sugar in the second are more

T: You depended on what? The quantity of sugar . . .

T + Ss: is bigger

T: The quantity of sugar affects the sweetnes of solution. A jar of water and a small cup each full of water. I dissolved one spoon in each one of them. Which one is sweeter, Sajida?

Sajida: The solution in the cup will be sweeter than the solution in the jar. You depended on what here?

T: The quantity of water

T: In one case the solute

T+Ss: is different

T: In the other case the solvent

T + Ss: is different

T: Which is the solute and which is the solvent? Yes? (pointed at a student)

S: Sugar is the solute and water is the solvent.

T + Ss: Sugar is the solute and water is the solvent.

T: What do I call this solution in which water is the solvent? Yes? (pointed at a student)

S: Concentrated solution

Ss: Aqueous solution

T: Aqueous solution, when water is the solvent in a solution, we call it

T + Ss: Aqueous solution

100 T: This proportion between the quantity of water and the quantity of sugar, I will call concentration of solution.

T + Ss: Concentration of solution

T: Suppose I take two containers of the same volume (she drew them and wrote 1 liter on each one). One liter of water I dissolved 100 grams of sugar in the first and 100 grams of water in the second (she wrote sugar and water). This has 100 grams of sugar and this has 100 grams of water (some students made noises and one student stood up and talked).

S: The second should have sugar in it

T: Salt (teacher corrected and said salt and erased the word water and wrote salt instead). Is the proportion of sugar in water the same as the proportion of salt in water?

Ss: (Noises)

T: We come back to Avogadro's hypothesis

Ss: (Noises) Me, miss; Me, miss

T: Is the proportion...(repeated the question and added) since the solute is the same amount, Hamama?

Hamama: The number of molecules is different

T: The number of molecules is different. I have to consider the concentration of the solution which means the molecules of sugar in water and the number of molecules of salt in water (she repeated, I have to consider...) Avogadro said, the masses of molecules or volumes...what did Avagadro say? What did Avogadro say? Majida?

Majida: (no response)

Ss: (Noises)

T: (Adressing all the class) What is the problem class? Would you like me to give you an exam? or what? Return to the habit of expelling out?

(Few students raised their hands. T. picked one)

S: Equal volumes of different gases contain the same number of molecules

T: Equal volume, not necessary of gases, have...

T + Ss: The same number of molecules

T: Here do we have the same number of molecules? (pointed to a student)

S: No

T: I will see what is the number of molecules in this liter of solution of sugar and the number of molecules in this liter (of salt solution). I have to go back to the mole. How many molecules in one mole?

T + Ss: Avogadro's number

T: What is Avogadro's number?

T + Ss: 6.02×10^{23} molecules

T: How much is the mass of one mole. Which (thing) contain Avagadro's number of molecules (she repeated) which...and pointed at a student:

S: Molecular mass in grams

(T. wrote one mole = 6.02×10^{23})

T: Molecular mass in grams. Mass of a mole = moleculer mass in gram (she wrote molar mass = Molecular M grams). Where can I get the gramic molecular mass? From the molecular formula. What is the molecular formula of sugar, you took this in biology. Yes? (pointing at a student).

S: $C_6H_{12}0_6$

T + Ss: $C_6H_{12}0_6$

T: What is the salt? What is the name of it (picking one student)

S: NaCl

T + Ss: NaCl

T: Sodium

T + Ss: Chloride

T: I will try to calculate the

T + Ss: Molecular mass in grams for sugar and salt.

T: In order to see the number of molecules in one liter of each solution. The molecular mass is equal to the total number of atoms in it. Right or wrong?

Ss: Right

T: For sugar. How many 0 atoms?

T + Ss: 6

T: How many carbon atoms?

T + Ss: 6

130 T: and 12 atoms of hydrogen . . . 6 X

T + Ss: 16

T: + 12 X

T + Ss: 1

T: 6

T + Ss: X 12

T: plus

T + Ss: 72

T: equal to 180 grams. How much is the mass?

Ss: 180 grams

T: What is the molecular mass of NaCl? The total masses of...

T + Ss: Atom of Na and the mass of atom of chlorine

T: I look at the periodic table to see the molecular mass of sodium and chlorine. Sodium 29.9 we approximate it to 23 plus chlorine 35.5

T + Ss: 58.5

T: Those 58.5 are present where? (She wrote after 58.5 gram/mole)

Ss: in mole

T: those are present in

T + Ss: mole

T: 1 mole of sugar $C_6 H_{12} O_6$, assuming that it is glucose sugar, has 6.02×10^{23}

T: How much gm of sugar do I have (pointing at 100 gm)

T + Ss: 100 gm

T: In need to see how many molecules in 100 gm sugar. Right or wrong?

Ss: Right

T: Number of molecules of sugar

T + Ss: $\frac{6.02 \times 10^{23}}{180} \times 100$ molecules

T: I see now the number of molecules of salt
1 mole of salt (She wrote on chalkboard 6.02×10^{23} its mass 58.5
1 mole of salt

T + Ss: has Avagadro's number of molecules

T: I have 100 gm of salt. The number of molecules in 100 gm is

T + Ss: $\frac{6.02 \times 10^{23}}{58.5} \times 100$ molecules

143 T: Are these two numbers equal?

Ss: No
T: Are they equal to each other

Ss: No

T: Are the number of molecules of sugar and salt equal to each other?

Ss: No

T: Is the concentration of the two solutions equal

Ss: No

T: In concentration I did not use the mass of substance. I used

T + Ss: Number of molecules

T: As the number of molecules increases the concentration is increases. Which is bigger, this (salt) concentration or this (sugar)? The number of molecules of salt is

T + Ss: Larger than the number of molecules of sugar

T: Instead of talking about he number of molecules as concentration, they gave it an expression "the molarity, they gave it

T + Ss: the name of molarity

T: Now we come to molarity. We come

T + Ss: to molarity

153 T: (Teacher pointed to a student to clean the chalkboard, as she contnued talking). There is a relationship between the quantity of the solute and solvent, or between the mass of the substance and the mole. (She wrote on the right side of chalkboard: "Molarity" and pointed to a student who is still cleaning the left side of the chalkboard to sit down). They defined molarity and gave it special unit. They consider molarity to be the number of moles of the solute in a liter of

S: water.

T: Not necessarily water, the solvent in general, in a liter of the solution. We wlll prepare a solution which has a concentration of 1 mole in a liter. Suppose we need to prepare 1 liter of the solution of NaCl of...

T + Ss: Sodium Chloride

T: Which is

T + Ss: Table salt

T: The process will be carried out as follows: I use volumetric flask (T. Started drawing the flask) it has a stopper. Its volume is (she wrote on chalkboard 1000 milliliter) How many milliliter yes? (Pointing to a student)

S: 1000 milliliter

T: 1000 milliliter

T: How can I know the volume? There is a mark on the flask which indicates the volume up to it is

T + Ss: 1000 milliliter

T: In the preparation, I have to use pure distilled water. Tap water has salts. If you taste it you will taste the salts. For this reason, the tap water of our town in particular has salts, its taste is

t + Ss: Salty

T: The taste of the water of Amman City is different from the taste of water in our town. What is the volume of the solution which I need to prepare?

Ss: One mole

T: One mole. What is the mass of one mole of NaCl. I have just calculated it?

165 S: 58.5 grams

T: What did I call 58.5 grams. (Pointed at a student)

S: Gramic molecular mass

T + Ss: Gramic molecular mass

T: I take table salt and weigh how much?

T + Ss: 58.5 grams

T: I put them in the...

Ss: Flask

T: In the flask then I add distilled water and stir to dissolve them. If the whole quantity is dissolved in

T + Ss: the water

T: I get a solution which has a concentration of 1 mole

T + Ss: in liter

T: One mole 1 liter. If I count the number of molecules dissolved in water, what is the number of molecules? Yes? (pointing to a student)

S: Avagadro's number

T: Avagadro's number, because it has one mole, so the number of molecules is

T + Ss: 6.02×10^{23} molecules

T: Do I find atoms in the solution? (pointing to a student)

S: No, miss

T: No. Because I dissolved molecules of NaCl, I will find molecules of sodium chloride. Each molecule is made up of one atom of chlorine and one atom of...

T + Ss: Sodium

175 T: When I used 58.5 grams of NaCl in the laboratory...
What is the quantity, here? Large one. I can use less amount and prepare a solution of 1 mole/liter. Instead of using this whole amount of NaCl and waste it, I can use less amount, but to prepare a solution of the same concentration, one mole

T + Ss: per liter

T: Clean the board. I need to decrease the solute quantity, what should I decrease also at the same time?

T + Ss: the solvent

T: For example if I have two spoons of sugar and I need three cups of tea, if I add the two spoons to the three cups, the tea will be bitter. So I have to decrease the amount of tea in each cup. In order to decrease the amount of sugar, I have to decrease the amount of what in order to concentration. Constant?

T + Ss: the amount of water

T: Suppose I need to prepare 100 milliliter instead of 1 liter, how much NaCl should I dissolve in order to keep concentration at 1 mole 1 liter? When I prepared 1 mole/liter, I took 1000 milliliter. If I need to prepare 100 mil., how much the concentration will be? (She wrote on chalkboard) 1000 mil., 1 mole/liter
100 mil? I multiply . . .

T + Ss: Reciprocal multiplication

186 T: I get 0.1 mole, where should I dissolve this?

T + Ss in 100 mil.

T: in this case I use a smaller flask than one liter. Its capacity is 100 mil. When I prepared 1 mole, I used one . . .

T + Ss: gramic molecular mass

196 T: One mole or 58.5 gram. To prepare 0.1 mole the mass of NaCl is
(on chalkboard) 1 mole = 1 gramic molecular mass 58.5
0.1 ?

the mass of NaCl is $\frac{58.5 \text{ X } 0.1}{1}$ = 58.5 grams
where should I dissolve this:

T + Ss: in 100 mil

T: what is the concentration of this solution

T + Ss: 1 mole/liter

T: What did I decrease... the solute

T + Ss: and the solvent

T: I will prove that the concentration is

T + Ss: one mole/liter

T: I go back to what one mole represents. (Repeat the same statement). What did I call one mole? (She wrote "Molarity" on board)

Ss: Molarity

T + Ss: Molarity

T: What was the mass of the solute in one mole (1 mole/liter) (She pointed at 0.1)

T + Ss: 0.1 mole

T: What was the volume of the solution

Ss: 100 mil

T: 100 mil out of 1000 mil is $\frac{100}{1000}$ + 0.1 (she wrote that on the board then wrote and uttered): Molarity = $\frac{0.1}{0.1}$ =1

To prepare one mole/liter, what did I use? I used less quantities. Instead of using 1000 mil, how much I used here?

T + Ss: 5.85 grams

207 T: Always...(she read what she was writing)

$$\text{Molarity} = \frac{\text{the mass of solute in mole}}{\text{volume of solution in liter}}$$

Who is willing to come to the board? (Few hands were raised up). What about the rest of the class? Let us solve a problem. Rania. Let us see what is Rania going to do.

214 T: (Constructing a problem and directing the talk to Rania) Prepare a solution of NaCl with concentration of 2 mole/liter. In other words: 2 molarity. (Rania wrote 2 mole for each... the teacher asked her to put a dash instead of for each...)

Rania: We see the mass required to prepare 1 mole of NaCl.

T: Right the mass required to prepare 1 mole of NaCl. What was the mass of 1 mole?

T + Ss: 58.5 grams

T: But what should I prepare?

T + Ss: 2 moles

T: Of course the volume of the solution is one liter. I say 2 moles for a liter

Rania: I calculate the mole of NaCl. (Rania wrote 1 mole = 58.5 gram. 2 moles = ?)

T: The mass of one mole of NaCl is 58.5 grams. I need to prepare 2 moles/liter. Did the volume differ?

T + Ss: No

221 T: The volume here is one liter of water (required for 1 mole/liter) and here also, the volume is one liter of water (required for w mole/liter). Where is the difference? In the mole and grams. Write Rania, the mass of NaCl needed...

$\frac{85.5 \text{ X } 2}{1}$ grams. I dissolve twice as much of the molecular mass. Go to your place Rania. Thank you. Do you know what if I need to prepare half mole?

T + Ss: We need half the quantity of NaCl

229 T: Right. I need half the quantity of NaCl is there any question? (No response) All of you, on your notebook, start to solve the problem No. 1. (She looked at her watch and said) there is no time left. Next time solve problem 1, 2, 3. Prepare solubility until the beginning of electrolytes solutions, page 47. O' Class, you have not studied nor you have prepared well today. Is it because it is the end of the week. Last time you were not prepared. Today you are not prepared. (Rania, the classroom monitor, brought the abscentees record for the teacher to sign. Everyone is moving with a lot of noise; the time is now 9:36).

APPENDIX E

EXTRACTS FROM LESSONS 3-1 AND 3-2
RELATED TO TEACHING FARADAY"S EXPERIMENTS

EXTRACTS FROM LESSONS 3-1 AND 3-2

RELATED TO TEACHING FARADAY'S EXPERIMENTS

T: So what is the result that I can conclude? If I let the same quantity of electricity pass through different solutions of mercuric ions, and I find equal quantities of mercury precipitation, what is the first conclusion about Faraday's experiment? (Silence...Five students raised their hands: Jamila, Hamama, Rania, Muna D. and Manal.)

T: (nervous) What about the others? Yes, Jamila.

Jamila: Equal quantities of electricity precipitate equal quantities of matter.

T: (repeated Jamila's response and made some more illustrations about the relationship between the mass of matter precipitated in the experiment and the current intensity and the time used. Then asked:) what is the relationship between time and intensity of electrical current? (Only three student raised their hands. The teacher called on Buthain).

Buthain: Intensity $= \frac{1}{\text{TIME}}$

T: Intensity is measured in ampers. There is a law which relate these factors together we took it in the first semester. Okay, what is the law of the quantity of electricity? (She repeated the question three times while she was looking at the board and adding the units to the time and the current intensity. Then she paraphrased the question once more.) What is the quantity of electricity? (Very few hands were raised. She called on Hamama to respond.)

Hamama: Intensity of the current times the time in seconds.

T: (Repeated the answer and added: ampers times seconds. Then the teacher made a lengthy illustration giving some numerical examples and working them out on the board and makeing final conclusion about the relationship between the quantity of electricity and the units of matter) In other words: electricity passes in the solution in a form of units. Certain units of electricity belong to one atom of the matter, (she repeated this statement twice). In other words, each atom will have a certain quantity of electricity, will have one unit or two, but not one and a half. Units are whole numbes. This is Faraday's first law. (She started to clean the board while she was continuing her statement. Then she asked: What do you understand from what I have said, Sajida, without waiting for students to raise hands.)

Sajida: (silence)

T: (repeated the question) Go ahead Sajida. We are not asking about something new. We are asking about something we were explaining. For how long will you continue like this? This means that you do not understand science. Let us expel you outside from the science lesson, or let us forget about science. Science is beyond your level. Listen to another one so you may understand. Yes? (pointing at a student without calling her name).

S: The quantity of electricity is direct proportional to the quantity of the precipitated substance.

T: (Repeated the students response and made more elaboration and wrote the definition of Faraday's first law on the board...then moved to the second law. The second law was presented quickly as it is in the textbook, using the board to draw the diagrams and involving the class in chorus responses and a few students in responding to some rhetorical questions. Toward the end of the lesson, she turned the students attention to the relationship between the masses of precipated elements and the atomic mases of those elements using the data on the board.

The first question was: These are the masses of the precipitated substance and these are the atomic masses (pointing to the data on the board). What is this kind of relationship? 108 (At mass of Ag) precipitated 6.48 grams. 23 (atomic mass of Na) the precipitated mass is 1.28, what is the kind of relationship? She pointed at Muna D.)

Muna D: Inverse relationship

Ss: (Spontaneous chorus response): direct relationship!

T: Stand up Muna. Why did you say inverse?

Muna: (Silence)

T: So the precipated quantity is direct proportion to the atomic mass. The the teacher concluded the lesson by relating the number of moles to each other and found the proportion to be 6:2:3:6 which is a simple numerical relationship and stated the conclusion of this to be: The quantity of electricity passed through the solutions caused different numbes of moles to precipitate, each quantity of electricity will be possessed by a certain number of atoms, either the same number or multiple to it, with a simple numerical proportions.

Next time...(directions about the following lesson and homework assignment)

From Lesson 3-2 in the Lab: Started the lesson by asking students about the first conclusion made by Faraday. Manal stated Faraday's first law correctly. The teacher then moved on to write on the board the data resulted form studying Faraday's second law; and to repeat the kinds of inferences she made last lesson then she made the following inferences:

T: The quantities of precipitated substances have simple numerical proportion among them. We said the quantity of electricity represents units...each number of units are possessed by one atom of the precipitated substance. Electricity is made of electrical charge. Because the atom possesses several units of electricity, so the atom carries the electrical charge. What are these charges? What is electricity? It is made up of material particles that have electrical charges. These charges are found in a similar way in all atoms. I call this charge the electron. Atoms have material particles with negative charges called electrons. Thompson calculated the amount of electrical charge of the electron and found it to be 1.6×10^{-19} Coulumb. (Most of these statements were repeated twice.) Of course the definition of the second law of Faraday is that: the quantity of the precipitated substance is in direct proportion to the equibalent mass. Did not we say that?

Ss: Yes

T: When the atomic mass increases the quantity of precipitated substance is increased. Now we move to the experiments of electrical discharge.

Lesson 3-3

We are still in (Expanding the Atomic Model). We have arrived to a certain model of atom. Thompson's model. We said that this model was able to explain few things and was not able to explain others. Such as the Linear spectra of elements. So this model was discarded and a new scientist came. His name is Rutherford. (There made no review of Faraday's Laws).

APPENDIX F

STUDENTS' RESPONSES ON ALTERNATIVE PROPOSITIONS TESTED IN MULTIPLE CHOICE TESTS

Key for Proposition Codes and Test Codes

The proposition code has four parts:

First: A letter T refers to propositions of tests.

Second: A number refers to chapter in the textbook (1, 2, or 3).

Third: A number refers to the item number in the text (1-25 for test of Chapter One, 1-30 for test of Chapter Two, 1-22 for pretest of Chapter Three, and 1-33 for posttest of Chapter Three.

Four: A number of the choice in the item: 1-4.

Example: T:3:15:2 refers to a proposition in the second choice of item 15 in the test of Chapter Three.

The test code has two parts:

First: A number of the test which is the same as the number of the chapter in the textbook, 1, 2, or 3.

Second: A number (a) refers to test given prior to instruction (pretest) or (b) refers to the test given after instruction (posttest).

Example: Test 3.2 refers to the posttest of Chapter Three.

Fa
Alternative Propositions Tested in Chapter I

Proposition Code	The Proposition	True/False	Number of Students Responding: Pretest	Posttest
T:1:1:1	Experiments conducted by scientists in their search for the structure of matter cannot be repeated except by scientists.	F	11	15
T:1:1:2	Experiments conducted by scientists in their search for the structure of matter can be repeated by anyone.	T	6	14
T:1:1:3	Experiments conducted by scientists in their search for the structure of matter did not provide evidence on the existence of atoms and molecules.	F	5	5
T:1:1:4	Experiments conducted by scientists in their search for the structure of matter proved that the molecule is the smallest part of matter.	F	29	19
T:1:2:1	When a scientist arrives at some conclusions, depending on practical experiments, the conclusions are always correct.	F	2	1
T:1:2:2	When a scientist arrives at some conclusions, depending on practical experiments, the conclusions are temporal and subject to change.	T	16	25
T:1:2:3	When a scientist arrives at some conclusions, depending on practical experiments, the conclusions cannot be judged until other scientists also arrive at them.	F	32	15
T:1:2:4	When a scientist arrives at some conclusions, depending on practical experiments, the conclusios are incorrect if prevailing theories cannot explain them.	F	3	12

Proposition Code	The Proposition	True/False	Number of Students Responding: Pretest	Number of Students Responding: Posttest
T:1:3:1	The study of gas behavior provided important information on atomic and molecular structure of matter because particles of gas are easy to study (a).	F	4	2
T:1:3:2	The study of gas behavior provided important information on atomic and molecular structure of matter because of the possibility of generalizing the result about gas to other states of matter (b).	F	6	6
T:1:3:3	The study of gas behavior provided important information on atomic and molecular structure of matter because of the possibility of changing substances into the gaseous state (c).	F	1	3
T:1:3:4	The study of gas behavior provided important information on atomic and molecular structure of matter because of a, b, and c.	T	42	41
T:1:4:1	The relationship which describes the regular behavior of a natural phenomenon is called a fact.	F	10	2
T:1:4:2	The relationship which describes the regular behavior of a natural phenomenon is called a law.	T	21	44
T:1:4:3	The relationship which describes the regular behavior of a natural phenomenon is called a phenomenon.	F	14	3
T:1:4:4	The relationship which describes the regular behavior of a natural phenomenon is called a hypothesis.	F	8	3
T:1:5:1	The law of definite proportion states that elements combine with each other spontaneously.	F	3	0

Proposition Code	The Proposition	True/False	Number of Students Responding: Pretest	Posttest
T:1:5:2	The law of definite proportion states that elements combine with each other producing heat.	F	13	1
T:1:5:3	The law of definite proportion states that elements combine with each other in definite mass proportion.	T	32	46
T:1:5:4	The law of definite proportion states that elements combine with each other in definite volume proportion.	F	5	5
T:1:6:1	Dalton's atomic theory can't explain the definite composition of substances.	F	6	9
T:1:6:2	Dalton's atomic theory can't explain the way in which substances can react with each other.	F	13	11
T:1:6:3	Dalton's atomic theory can't explain the proportion in which substances react with each other.	F	12	10
T:1:6:4	Dalton's atomic theory can't explain the the structure of isotopes.	T	19	23
T:1:7:1	The mass of Avogadro's number of any chemical unit is called atomic weight.	F	21	4
T:1:7:2	The mass of Avogadro's number of any chemical unit is called atomic number.	F	10	1
T:1:7:3	The mass of Avogadro's number of any chemical unit is called atomic mass.	F	4	1
T:1:7:4	The mass of Avogadro's number of any chemical unit is called the mole.	T	18	47

Proposition Code	The Proposition	True/False	Number of Students Responding: Pretest	Posttest
T:1:8:1	If Avogadro's number is 6.02 x 10^{23} and the mass of a hydrogen mole is two grams, then the mass of one atom of hydrogen is 6.02 x 10^{23} grams.	F	9	3
T:1:8:2	If Avogadro's number is 6.02 x 10^{23} and the mass of a hydrogen mole is two grams, then the mass of one atom of hydrogen is (½) x 6.02 x 10^{23} grams.	F	11	5
T:1:8:3	If Avogadro's number is 6.02 x 10^{23} and the mass of a hydrogen mole is two grams, then the mass of one atom of hydrogen is (2/6.02) x 10^{23} grams.	F	16	15
T:1:8:4	If Avogadro's number is 6.02 x 10^{23} and the mass of a hydrogen mole is two grams, then the mass of one atom of hydrogen is (2/6.02) x 10^{-23} grams.	T	15	30
T:1:9:1	Gas laws can be explained by Dalton's theory.	F	5	13
T:1:9:2	Gas laws can be explained by molecular kinetic theory.	T	35	33
T:1:9:3	Gas laws can be explained by Avogadro's hypothesis.	F	9	3
T:1:9:4	Gas laws can be explained by modern atomic theory.	F	4	3
T:1:10:1	The statement "Equal volumes of different gases have the same number of molecules at similar conditions of pressure and temperature" is called Avogadro's hypothesis.	T	9	46
T:1:10:2	The statement "Equal volumes of different gases have the same number of molecules at similar conditions of pressure and temperature" is called Gay-Lusac law.	F	0	0

Proposition Code	The Proposition	True/False	Number of Students Responding Pretest	Posttest
T:1:10:3	The statement "Equal volumes of different gases have the same number of molecules at similar conditions of pressure and temperature" is called general gas law.	F	26	1
T:1:10:4	The statement "Equal volumes of different gases have the same number of molecules at similar conditions of pressure and temperature" is called the law of definite proportion.	F	16	6
T:1:11:1	Dalton's theory proposed that the atom has a massive nucleus.	F	3	1
T:1:11:2	Dalton's theory proposed that atoms of the same element have similar masses.	T	8	46
T:1:11:3	Dalton's theory proposed that electrons of an atom are found in orbits.	F	36	5
T:1:11:4	Dalton's theory proposed that negative charges in an atom are distributed evenly.	F	4	1
T:1:12:1	If the volume occupied by one mole of oxygen molecules at STP is 22.4 liters, then the volume occupied by one mole of hydrogen molecules is (2/32) x 22.4 liters.	F	9	3
T:1:12:2	If the volume occupied by one mole of oxygen molecules at STP is 22.4 liters, then the volume occupied by one mole of hydrogen molecules is (1/32) x 22.4 liters.	F	11	5
T:1:12:3	If the volume occupied by one mole of oxygen molecules at STP is 22.4 liters, then the volume occupied by one mole of hydrogen molecules is 22.4 liters.	T	22	35

Proposition Code	The Proposition	True/False	Number of Students Responding: Pretest	Posttest
T:1:12:4	If the volume occupied by one mole of oxygen molecules at STP is 22.4 liters, then the volume occupied by one mole of hydrogen molecules is (½) x 22.4 liters.	F	10	10
T:1:13:1	Real gas behaves similarly to the behavior of ideal gas only in the condition that its molecules do not have volume (a).	F	4	4
T:1:13:2	Real gas behaves similarly to the behavior of ideal gas only in the condition that its molecules do not have mass (b).	F	6	2
T:1:13:3	Real gas behaves similarly to the behavior of ideal gas only in the condition that its molecules do not have attraction forces (c).	F	8	4
T:1:13:4	Real gas behaves similarly to the behavior of ideal gas only in conditions a and c.	T	33	41
T:1:14:1	Atomic theory on the structure of matter explains a number of laws called gas laws.	F	8	3
T:1:14:2	Atomic theory on the structure of matter explains a number of laws called Newton's laws of motion.	F	1	0
T:1:14:3	Atomic theory on the structure of matter explains a number of laws called laws of chemical composition.	T	13	18
T:1:14:4	Atomic theory on the structure of matter explains a number of laws called gas laws and laws of chemical composition.	F	31	31
T:1:15:1	A mole is the mass of Avogadro's number of real atoms of an element.	F	2	1
T:1:15:2	A mole is the mass of Avogadro's number of real molecules of an element or compound.	F	6	5

Proposition Code	The Proposition	True/False	Number of Students Responding: Pretest	Number of Students Responding: Posttest
T:1:15:3	T:1:15:1 and T:1:15:2 are both correct.	T	24	36
T:1:15:4	T:1:15:1 and T:1:15:2 are both incorrect.	F	19	10
T:1:16:1	Boyle's law is considered a description of a gas which is ideal.	T	14	43
T:1:16:2	Boyle's law is considered a description of a gas which is real.	F	12	8
T:1:16:3	Boyle's law is considered a description of a gas which has large molecules.	F	6	1
T:1:16:4	Boyle's law is considered a description of a gas which has high pressure.	F	17	1
T:1:17:1	The statement "Mercury reacts with oxygen to form two oxides and the proportion of the two masses of mercury which combine with a constant mass of oxygen is a simple numerical one" is a description of the law of conservation of matter.	F	14	9
T:1:17:2	The statement "Mercury reacts with oxygen to form two oxides and the proportion of the two masses of mercury which combine with a constant mass of oxygen is a simple numerical one" is a description of the law of definite proportion.	F	17	21
T:1:17:3	The statement "Mercury reacts with oxygen to form two oxides and the proportion of the two masses of mercury which combine with a constant mass of oxygen is a simple numerical one" is a description of the law of multiple proportion.	T	10	19

Proposition Code	The Proposition	True/False	Number of Students Responding: Pretest	Number of Students Responding: Posttest
T:1:17:4	The statement "Mercury reacts with oxygen to form two oxides and the proportion of the two masses of mercury which combine with a constant mass of oxygen is a simple numerical one" is a description of the law of reciprocal proportion.	F	10	4
T:1:18:1	A mole of Jordanian dinars (6×10^{23} JD) was distributed to the world's population. Each person's share was 1×10^{14} JD. The world population is 6×10^{23}.	F	12	11
T:1:18:2	A mole of Jordanian dinars (6×10^{23} JD) was distributed to the world's population. Each person's share was 1×10^{14} JD. The world population is 6×10^{14}.	F	7	6
T:1:18:3	A mole of Jordanian dinars (6×10^{23} JD) was distributed to the world's population. Each person's share was 1×10^{14} JD. The world population is 6000 million.	T	25	18
T:1:18:4	A mole of Jordanian dinars (6×10^{23} JD) was distributed to the world's population. Each person's share was 1×10^{14} JD. The world population is six million.	F	9	18
T:1:19:1	Chemical properties and characteristics of a substance are represented by the electron.	F	15	6
T:1:19:2	Chemical properties and characteristics of a substance are represented by the atom.	F	13	18
T:1:19:3	Chemical properties and characteristics of a substance are represented by the molecule.	T	11	17
T:1:19:4	Chemical properties and characteristics of a substance are represented by the nucleus.	F	13	12

Proposition Code	The Proposition	True/False	Number of Students Responding: Pretest	Number of Students Responding: Posttest
T:l:20:l	The smallest unit of a chemical substance which takes part in a chemical reaction is called an electron.	F	9	1
T:l:20:2	The smallest unit of a chemical substance which takes part in a chemical reaction is called an atom.	T	25	40
T:l:20:3	The smallest unit of a chemical substance which takes part in a chemical reaction is called a molecule.	F	18	9
T:l:20:4	The smallest unit of a chemical substance which takes part in a chemical reaction is called a nucleus.	F	1	3
T:l:2l:l	The substance which has molecules consisting of two or more kinds of atoms combined in a definite proportionn is called a compound.	T	29	48
T:l:2l:2	The substance which has molecules consisting of two or more kinds of atoms combined in a definite proportionn is called an element.	F	8	4
T:l:2l:3	The substance which has molecules consisting of two or more kinds of atoms combined in a definite proportionn is called a mixture.	F	15	1
T:l:2l:4	The substance which has molecules consisting of two or more kinds of atoms combined in a definite proportionn is called a solution.	F	1	0
T:l:22:l	An element is defined as follows: the set of symbols referring to the kinds and number of atoms in a molecule.	F	14	1
T:l:22:2	An element is defined as follows: pure substance made up of one kind of atoms.	T	15	28

Proposition Code	The Proposition	True/False	Number of Students Responding: Pretest	Posttest
T:1:22:3	An element is defined as follows: pure substance with molecules made up of more than one kind of atoms.	F	6	22
T:1:22:4	An element is defined as follows: the smallest unit which takes part in chemical reactions.	F	16	2
T:1:23:1	A molecule of ammonia is made up of two atoms.	F	3	3
T:1:23:2	A molecule of ammonia is made up of three atoms.	F	27	31
T:1:23:3	A molecule of ammonia is made up of four atoms.	T	10	17
T:1:23:4	A molecule of ammonia is made up of five atoms.	F	1	1
T:1:24:1	If the mass of one mole of hydrogen is two grams, then the number of moles of hydrogen molecules in 10 grams of hydrogen is 6.02×10^{23} moles.	F	2	1
T:1:24:2	If the mass of one mole of hydrogen is two grams, then the number of moles of hydrogen molecules in 10 grams of hydrogen is $(2/10) \times 6.02 \times 10^{23}$ moles.	F	16	32
T:1:24:3	If the mass of one mole of hydrogen is two grams, then the number of moles of hydrogen molecules in 10 grams of hydrogen is five moles.	T	28	13
T:1:24:4	If the mass of one mole of hydrogen is two grams, then the number of moles of hydrogen molecules in 10 grams of hydrogen is two moles.	F	6	6

Proposition Code	The Proposition	True/False	Number of Students Responding: Pretest	Posttest
T:1:25:1	The number of moles of oxygen molecules in one mole of molecules of sulfuric acid is one mole.	F	9	7
T:1:25:2	The number of moles of oxygen molecules in one mole of molecules of sulfuric acid is two mole.	F	11	7
T:1:25:3	The number of moles of oxygen molecules in one mole of molecules of sulfuric acid is three mole.	F	5	0
T:1:25:4	The number of moles of oxygen molecules in one mole of molecules of sulfuric acid is four mole.	T	28	38

Fb

Alternative Propositions Tested in Chapter II

Proposition Code	The Proposition	True or False	# of Studs. 2.2
T:2:1:1	The change in a substance from one state to another is used to determine the kind of substance (a).	F	1
T:2:1:2	The change in a substance from one state to another is used to determine the purity or impurity of the substance (b).	F	9
T:2:1:3	The change in a substance from one state to another is used to separating substances from each other (c).	F	2
T:2:1:4	The change in a substance from one state to another is used to determine a, b, and c.	T	40
T:2:2:1	Pure chlorine is found under normal pressure and temperature in the form of accumulation of atoms of gas.	F	16
T:2:2:2	Pure chlorine is found under normal pressure and temperature in the form of clusters of molecules of gas.	T	18
T:2:2:3	Pure chlorine is found under normal pressure and temperature in the form of clusters of ions of chlorine.	F	11
T:2:2:4	Pure chlorine is found under normal pressure and temperature in the form of evenly distributed molecules of chlorine in air.	F	8
T:2:3:1	The movement of molecules of a certain substance is greatest in its gaseous state.	T	35
T:2:3:2	The movement of molecules of a certain substance is greatest in its liquid state.	F	10
T:2:3:3	The movement of molecules of a certain substance is greatest in its solid state.	F	5
T:2:3:4	The movement of molecules of a certain substance is greatest in the state of the homogeneous aqueous solution.	F	3

Proposition Code	The Proposition	True or False	# of Studs. 2.2
T:2:4:1	If the melting point of pure sodium is 98 C and the boiling point is 889 C, then the freezing point of sodium is 98 C.	T	13
T:2:4:2	If the melting point of pure sodium is 98 C and the boiling point is 889 C, then the freezing point of sodium is -98 C.	F	22
T:2:4:3	If the melting point of pure sodium is 98 C and the boiling point is 889 C, then the freezing point of sodium is 889 C.	F	22
T:2:4:4	If the melting point of pure sodium is 98 C and the boiling point is 889 C, then the freezing point of sodium is 811 C.	F	13
T:2:5:1	As the evaporation process of a solution of salt in water increases, the boiling point of the solution is increased.	F	3
T:2:5:2	As the evaporation process of a solution of salt in water increases, the boiling point of the solution stays as it is.	T	34
T:2:5:3	As the evaporation process of a solution of salt in water increases, the boiling point of the solution is decreased.	F	10
T:2:5:4	As the evaporation process of a solution of salt in water increases, the boiling point of the solution is decreased first, then increased.	F	5

Proposition Code	The Proposition	True or False	# of Studs. 2.2
T:2:6:1	In the above diagram, a, b, and c describe the behavior of pure water, and d, e, and f describe the behavior of a solution during boiling. The segment e-f states that temperature changes during boiling the solution (a).	T	25
T:2:6:2	In the above diagram, a, b, and c describe the behavior of pure water, and d, e, and f describe the behavior of a solution during boiling. The segment e-f states that temperature stays constant during boiling the solution (b).	F	7
T:2:6:3	In the above diagram, a, b, and c describe the behavior of pure water, and d, e, and f describe the behavior of a solution during boiling. The segment e-f states that the solution boils at a lower temperature than the pure water (c).	F	3
T:2:6:4	In the above diagram, a, b, and c describe the behavior of pure water, and d, e, and f describe the behavior of a solution during boiling. The segment e-f states both (a) and (c).	F	17
T:2:7:1	Evaporation is different from boiling only in the fact that evaporation occurs at a certain temperature (a).	F	0

Proposition Code	The Proposition	True or False	# of Studs. 2.2
T:2:7:2	Evaporation is different from boiling only in the fact that molecules evaporate from all parts of the liquid (b).	F	2
T:2:7:3	Evaporation is different from boiling only in the fact that the evaporation rate increases as temperature increases (c).	T	12
T:2:7:4	Evaporation is different from boiling in a, b, and c above.	F	38
T:2:8:1	Pure substance is characterized only by having constant boiling and melting points at a certain pressure (a).	F	4
T:2:8:2	Pure substance is characterized only by being made of the same kind of atoms or molecules (b).	F	3
T:2:8:3	Pure substance is characterized only by having a constant vapor pressure at a certain temperature (c).	F	4
T:2:8:4	Pure substance is characterized by a, b and c.	T	41
T:2:9:1	Vapor pressure of a pure liquid depends only on atmospheric pressure (a).	F	4
T:2:9:2	Vapor pressure of a pure liquid depends only on temperature (b).	F	2
T:2:9:3	Vapor pressure of a pure liquid depends only on the kind of liquid (c).	F	1
T:2:9:4	Vapor pressure of a pure liquid depends on b and c.	T	44
T:2:10:1	If the vapor pressure of A at 20 C is 18 mm and the vapor pressure of B at 20 C is 45 mm, then the boiling point of A is characterized only by being higher than that of B (a).	T	9

Proposition Code	The Proposition	True or False	# of Studs. 2.2
T:2:10:2	If the vapor pressure of A at 20 C is 18 mm and the vapor pressure of B at 20 C is 45 mm, then the boiling point of A is characterized only by being lower than that of B (b).	F	17
T:2:10:3	If the vapor pressure of A at 20 C is 18 mm and the vapor pressure of B at 20 C is 45 mm, then the boiling point of A is characterized only by its dependence on atmospheric pressure (c).	F	8
T:2:10:4	If the vapor pressure of A at 20 C is 18 mm and the vapor pressure of B at 20 C is 45 mm, then the boiling point of A is characterized by both a and c.	F	20
T:2:11:1	The only solution in this list--bronze, ammonia, pop--is bronze.	F	0
T:2:11:2	The only solution in this list--bronze, ammonia, pop--is ammonia.	F	17
T:2:11:3	The only solution in this list--bronze, ammonia, pop--is pop.	F	8
T:2:11:4	Bronze, ammonia, and pop are all solutions.	T	27
T:2:12:1	The only colloidal solution in this list--blood, jello, and milk--is blood.	F	1
T:2:12:2	The only colloidal solution in this list--blood, jello, and milk--is jello.	F	4
T:2:12:3	The only colloidal solution in this list--blood, jello, and milk--is milk.	F	2
T:2:12:4	Blood, jello, and milk are all colloidal solutions.	T	45
T:2:13:1	Electrical current is conducted by a solution of table salt in water.	T	43
T:2:13:2	Electrical current is conducted by a solution of sugar in water.	F	2

Proposition Code	The Proposition	True or False	# of Studs. 2.2
T:2:13:3	Electrical current is conducted by a solution of alcohol in water.	F	4
T:2:13:4	Electrical current is conducted by a solution of distilled water.	F	3
T:2:14:1	A mixture of solid in liquid is always considered a solution.	F	11
T:2:14:2	A mixture of liquid in liquid is always considered a solution.	F	18
T:2:14:3	A mixture of gas in gas is always considered a solution.	T	14
T:2:14:4	A mixture of liquid in solid is always considered a solution.	F	6
T:2:15:1	The amount of dissolved gas in a liquid is greatest under high pressure and high temperature.	F	16
T:2:15:2	The amount of dissolved gas in a liquid is greatest under low pressure and high temperature.	F	11
T:2:15:3	The amount of dissolved gas in a liquid is greatest under low pressure and low temperature.	F	5
T:2:15:4	The amount of dissolved gas in a liquid is greatest under high pressure and low temperature.	T	21
T:2:16:1	The scientific principle of adding antifreeze substance to a car radiator is the fact that the freezing point of a solution is higher than that of pure water.	F	15
T:2:16:2	The scientific principle of adding antifreeze substance to a car radiator is the fact that the freezing point of a solution is lower than that of pure water.	T	15

Proposition Code	The Proposition	True or False	# of Studs. 2.2
T:2:16:3	The scientific principle of adding antifreeze substance to a car radiator is the fact that the temperature stays constant while freezing a solution.	F	16
T:2:16:4	The scientific principle of adding antifreeze substance to a car radiator is the fact that the added substance reacts with water giving off heat.	F	7
T:2:17:1	If the mass of a mole of sugar is 342 grams and a liter of aqueous solution of sugar has 68.4 grams of sugar, then the molarity of this solution is 0.2 moles/liter.	T	14
T:2:17:2	If the mass of a mole of sugar is 342 grams and a liter of aqueous solution of sugar has 68.4 grams of sugar, then the molarity of this solution is 2.0 moles/liter.	F	14
T:2:17:3	If the mass of a mole of sugar is 342 grams and a liter of aqueous solution of sugar has 68.4 grams of sugar, then the molarity of this solution is 0.02 moles/liter.	F	17
T:2:17:4	If the mass of a mole of sugar is 342 grams and a liter of aqueous solution of sugar has 68.4 grams of sugar, then the molarity of this solution is 20.0 moles/liter.	F	8
T:2:18:1	If the mass of a mole of sugar is 342 grms, the mass of sugar required to make a liter of solution with a 0.5 mole/liter concentration is 342 grams.	F	10
T:2:18:2	If the mass of a mole of sugar is 342 grms, the mass of sugar required to make a liter of solution with a 0.5 mole/liter concentration is 684 grams.	F	8
T:2:18:3	If the mass of a mole of sugar is 342 grms, the mass of sugar required to make a liter of solution with a 0.5 mole/liter concentration is 171 grams.	T	24

Proposition Code	The Proposition	True or False	# of Studs. 2.2
T:2:18:4	If the mass of a mole of sugar is 342 grms, the mass of sugar required to make a liter of solution with a 0.5 mole / liter concentration is 0.5 grams.	F	9
T:2:19:1	If a mass of one mole of sugar is 342, then the volume of solution which is 0.01 M required to dissolve 3.42 grams of sugar is 10.0 liters.	F	5
T:2:19:2	If a mass of one mole of sugar is 342, then the volume of solution which is 0.01 M required to dissolve 3.42 grams of sugar is 1.0 liters.	T	10
T:2:19:3	If a mass of one mole of sugar is 342, then the volume of solution which is 0.01 M required to dissolve 3.42 grams of sugar is 0.1 liters.	F	17
T:2:19:4	If a mass of one mole of sugar is 342, then the volume of solution which is 0.01 M required to dissolve 3.42 grams of sugar is 0.01 liters.	F	19
T:2:20:1	If the solubility of silver nitrate in water is 13 moles/liter at 20 C, then one liter of solution which has 14 moles $AgNO_3$ is considered a saturated solution.	F	10
T:2:20:2	If the solubility of silver nitrate in water is 13 moles/liter at 20 C, then one liter of solution which has 14 moles $AgNO_3$ is considered an under-saturated solution.	F	4
T:2:20:3	If the solubility of silver nitrate in water is 13 moles/liter at 20 C, then one liter of solution which has 14 moles $AgNO_3$ is considered an over-saturated solution.	T	25
T:2:20:4	If the solubility of silver nitrate in water is 13 moles/liter at 20 C, then one liter of solution which has 14 moles $AgNO_3$ is considered having a state depending on the temperature.	F	14

Proposition Code	The Proposition	True or False	# of Studs. 2.2
T:2:21:1	If the solubility of silver nitrate in water at 20 C is 13 moles/liter and a quantity of silver nitrate stays undissolved in spite of continuous stirring, then the solution is called saturated.	T	28
T:2:21:2	If the solubility of silver nitrate in water at 20 C is 13 moles/liter and a quantity of silver nitrate stays undissolved in spite of continuous stirring, then the solution is called under-saturated.	F	4
T:2:21:3	If the solubility of silver nitrate in water at 20 C is 13 moles/liter and a quantity of silver nitrate stays undissolved in spite of continuous stirring, then the solution is called super-saturated.	F	13
T:2:21:4	If the solubility of silver nitrate in water at 20 C is 13 moles/liter and a quantity of silver nitrate stays undissolved in spite of continuous stirring, then the solution is difficult to identify its kind.	F	5
T:2:22:1	If the solubility of silver nitrate in water at 20 C is 13 moles/liter, then the mass of dissolved $AgNO_3$ in one liter of saturated solution at 10 C will be 13 moles (a).	F	3
T:2:22:2	If the solubility of silver nitrate in water at 20 C is 13 moles/liter, then the mass of dissolved $AgNO_3$ in one liter of saturated solution at 10 C will be less than 13 moles (b).	T	19
T:2:22:3	If the solubility of silver nitrate in water at 20 C is 13 moles/liter, then the mass of dissolved $AgNO_3$ in one liter of saturated solution at 10 C will be more than 13 moles (c).	F	4
T:2:22:4	If the solubility of silver nitrate in water at 20 C is 13 moles/liter, then the mass of dissolved $AgNO_3$ in one liter of saturated solution at 10 C will be different than a, b, or c.	F	24

Proposition Code	The Proposition	True or False	# of Studs. 2.2
T:2:23:1	The lamp in an electrical circuit containing solution A will glow brighter than one containing solution B. This means that the concentration of A is higher than that of B.	F	12
T:2:23:2	The lamp in an electrical circuit containing solution A will glow brighter than one containing solution B. This means that the concentration of ions is higher in B.	F	2
T:2:23:3	The lamp in an electrical circuit containing solution A will glow brighter than one containing solution B. This means that A is a stronger electrolyte than B.	T	37
T:2:23:4	The lamp in an electrical circuit containing solution A will glow brighter than one containing solution B. This means that B is a stronger electrolyte than A.	F	2
T:2:24:1	Petroleum components are separated from each other using a method of separation called fractional distillation.	T	34
T:2:24:2	Petroleum components are separated from each other using a method of separation called extraction.	F	15
T:2:24:3	Petroleum components are separated from each other using a method of separation called normal distillation.	F	2
T:2:24:4	Petroleum components are separated from each other using a method of separation called crystillazation.	F	2
T:2:25:1	Normal distillation is used to separate solvent liquid from solids dissolved in it.	T	37
T:2:25:2	Normal distillation is used to separate a mixture of liquids which dissolve each other.	F	4
T:2:25:3	Normal distillation is used to separate liquids which have close boiling points.	F	5

Proposition Code	The Proposition	True or False	# of Studs. 2.2
T:2:27:4	The electrical charges carried on particles of the colloidal solution are formed as a result of the disassociation of molecules of the particles or attracting ions by those particles.	T	38
T:2:28:1	The particles of a colloidal solution are characterized by a certain diameter of the particle's being larger than 10^4 Angestrum.	F	13
T:2:28:2	The particles of a colloidal solution are characterized by being distributed in the solution unevenly.	F	10
T:2:28:3	The particles of a colloidal solution are characterized by continuous and random movement in broken lines.	T	23
T:2:28:4	The particles of a colloidal solution are characterized by their ability to pass light rays through the solution so the rays will not be seen.	F	7
T:2:29:1	The solubility of a substance in a solvent depends only on the type of the solvent liquid.	F	0
T:2:29:2	The solubility of a substance in a solvent depends only on the type of the dissolved solute.	F	0
T:2:29:3	The solubility of a substance in a solvent depends only on temperature.	F	2
T:2:29:4	The solubility of a substance in a solvent depends on the type of solvent, the type of solute, and the temperature.	T	49
T:2:30:1	If the saturated vapor pressure of water at 60 C is equal to 160 mm, then the pressure required to make the water boil at 60 C is equal to 160 mm.	T	25
T:2:30:2	If the saturated vapor pressure of water at 60 C is equal to 160 mm, then the pressure required to make the water boil at 60 C is equal to 760 mm.	F	10

Proposition Code	The Proposition	True or False	# of Studs. 2.2
T:2:25:4	Normal distillation is used to separate salts whose solubilities are influenced by heat.	F	7
T:2:26:1	If condensing vapor in the distillation process is called liquid A and the remaining liquid from separating crystals in the filtration process is called B, then A is a saturated solution and B is a pure substance.	F	9
T:2:26:2	If condensing vapor in the distillation process is called liquid A and the remaining liquid from separating crystals in the filtration process is called B, then A is a pure substance and B is a saturated solution.	T	11
T:2:26:3	If condensing vapor in the distillation process is called liquid A and the remaining liquid from separating crystals in the filtration process is called B, then A and B are both pure substances.	F	24
T:2:26:4	If condensing vapor in the distillation process is called liquid A and the remaining liquid from separating crystals in the filtration process is called B, then A and B are both saturated solutions.	F	8
T:2:27:1	The electrical charges carried on particles of the colloidal solution are formed as a result of scattering the light directed to the colloidal particles.	F	3
T:2:27:2	The electrical charges carried on particles of the colloidal solution are formed as a result of the disassociation of molecules forming the particles and nothing else.	F	6
T:2:27:3	The electrical charges carried on particles of the colloidal solution are formed as a result of the ability of colloidal particles to attract ions from the solution and nothing else.	F	3

Proposition Code	The Proposition	True or False	# of Studs. 2.2
T:2:30:3	If the saturated vapor pressure of water at 60 C is equal to 160 mm, then the pressure required to make the water boil at 60 C is equal to 600 mm.	F	10
T:2:30:4	If the saturated vapor pressure of water at 60 C is equal to 160 mm, then the pressure required to make the water boil at 60 C is equal to 60 mm.	F	6

Fc

Alternative Propositions Tested in Chapter III

Proposition Code	The Proposition	True/False	Number of Students Responding: Pretest	Number of Students Responding: Posttest
T:3:1:1	The number of kinds of atoms in an ammonia molecule NH_3 is one kind.	F	7	2
T:3:1:2	The number of kinds of atoms in an ammonia molecule NH_3 is two kinds.	T	22	43
T:3:1:3	The number of kinds of atoms in an ammonia molecule NH_3 is three kinds.	F	18	8
T:3:1:4	The number of kinds of atoms in an ammonia molecule NH_3 is four kinds.	F	3	0
T:3:2:1	The number of neutrons in an atom of deuterium is one neutron.	T	16	24
T:3:2:2	The number of neutrons in an atom of deuterium is two neutrons.	F	15	11
T:3:2:3	The number of neutrons in an atom of deuterium is three neutrons.	F	10	14
T:3:2:3	The number of neutrons in an atom of deuterium is four neutrons.	F	3	1
T:3:3:1	If the isotope of lithium has three protons, four neutrons, and three electrons, then its atomic mass is three.	F	5	3
T:3:3:2	If the isotope of lithium has three protons, four neutrons, and three electrons, then its atomic mass is six.	F	4	40
T:3:3:3	If the isotope of lithium has three protons, four neutrons, and three electrons, then its atomic mass is seven.	T	17	10
T:3:3:4	If the isotope of lithium has three protons, four neutrons, and three electrons, then its atomic mass is ten.	F	25	0

Proposition Code	The Proposition	True/False	Number of Students Responding Pretest	Posttest
T:3:4:1	Since the atom is neutral, the number of electrons is equal to the number of orbits.	F	14	3
T:3:4:2	Since the atom is neutral, the number of electrons is equal to the number of protons.	T	11	38
T:3:4:3	Since the atom is neutral, the number of electrons is equal to the number of neutrons.	F	7	7
T:3:4:4	Since the atom is neutral, the number of electrons is equal to the number of protons and neutrons.	F	17	5
T:3:5:1	Elements are made up of atoms which have the same atomic mass.	F	6	10
T:3:5:2	Elements are made up of atoms which have the same atomic number.	T	32	37
T:3:5:3	Elements are made up of atoms which have the same Avogadro's number.	F	4	4
T:3:5:4	Elements are made up of atoms which have the same number of neutrons.	F	4	1
T:3:6:1	When an atom loses valence electrons from its outside orbit, it is called a nucleus.	F	1	2
T:3:6:2	When an atom loses valence electrons from its outside orbit, it is called a free group.	F	20	15
T:3:6:3	When an atom loses valence electrons from its outside orbit, it is called an ion.	T	27	30
T:3:6:4	When an atom loses valence electrons from its outside orbit, it is called a molecule.	F	2	4
T:3:7:1	The chemical bond which is formed by the participation of two pairs of electrons is called the ionic bond.	F	15	3

Proposition Code	The Proposition	True/False	Number of Students Responding: Pretest	Posttest
T:3:7:2	The chemical bond which is formed by the participation of two pairs of electrons is called the covalent bond.	T	25	38
T:3:7:3	The chemical bond which is formed by the participation of two pairs of electrons is called the electronic bond.	F	4	2
T:3:7:4	The chemical bond which is formed by the participation of two pairs of electrons is called the multiple bond.	F	8	9
T:3:8:1	Ionic crystals are characterized by having a low melting point.	F	6	1
T:3:8:2	Ionic crystals are characterized by having the ability to conduct electricity.	F	29	21
T:3:8:3	Ionic crystals are characterized by having a high vapor pressure.	F	7	2
T:3:8:4	Ionic crystals are characterized by having a high melting point.	T	3	27
T:3:9:1	The most polarized molecule among CCl_4, $AlCl_3$, HCl, and CO_2 is CCl_4.	F	6	0
T:3:9:2	The most polarized molecule among CCl_4, $AlCl_3$, HCl, and CO_2 is $AlCl^3$.	F	16	7
T:3:9:3	The most polarized molecule among CCl_4, $AlCl_3$, HCl, and CO_2 is HCl.	T	15	40
T:3:9:4	The most polarized molecule among CCl_4, $AlCl_3$, HCl, and CO_2 is CO_2.	F	15	6
T:3:10:1	Properties of cathode rays depend on the kind of gas in the discharge tube (a).	F	10	5

Proposition Code	The Proposition	True/False	Number of Students Responding: Pretest	Posttest
T:3:10:2	Properties of cathode rays depend on the pressure of the gas in the tube (b).	F	3	3
T:3:10:3	Properties of cathode rays depend on the substance of the cathode (c).	F	13	2
T:3:10:4	Properties of cathode rays do not depend on a, b, or c.	T	23	42
T:3:11:1	Cathode rays are made up of electromagnetic rays.	F	10	4
T:3:11:2	Cathode rays are made up of electrons.	T	9	44
T:3:11:3	Cathode rays are made up of alpha particles.	F	15	4
T:3:11:4	Cathode rays are made up of gamma rays.	F	16	0
T:3:12:1	If the atomic mass of an element is 23 and its atomic number is 11, then the number of neutrons in the nucleus is equal to 12.	T	8	43
T:3:12:2	If the atomic mass of an element is 23 and its atomic number is 11, then the number of neutrons in the nucleus is equal to 11.	F	8	0
T:3:12:3	If the atomic mass of an element is 23 and its atomic number is 11, then the number of neutrons in the nucleus is equal to 23.	F	8	2
T:3:12:4	If the atomic mass of an element is 23 and its atomic number is 11, then the number of neutrons in the nucleus is equal to 34.	F	27	7
T:3:13:1	The two atoms of a hydrogen molecule are combined by a chemical bond called electronic bond.	F	0	0

Proposition Code	The Proposition	True/False	Number of Students Responding: Pretest	Number of Students Responding: Posttest
T:3:13:2	The two atoms of a hydrogen molecule are combined by a chemical bond called a covalent bond.	T	16	33
T:3:13:3	The two atoms of a hydrogen molecule are combined by a chemical bond called a hydrogen bond.	F	26	18
T:3:13:4	The two atoms of a hydrogen molecule are combined by a chemical bond called a metallic bond.	F	8	12
T:3:14:1	An atom of element A loses two electrons while reacting with element B; at the same time an atom of B gains one electron. The molecular formula of the resulting compound is AB.	F	14	2
T:3:14:2	An atom of element A loses two electrons while reacting with element B; at the same time an atom of B gains one electron. The molecular formula of the resulting compound is A_2B.	F	8	7
T:3:14:3	An atom of element A loses two electrons while reacting with element B; at the same time an atom of B gains one electron. The molecular formula of the resulting compound is AB_2.	T	24	42
T:3:14:4	An atom of element A loses two electrons while reacting with element B; at the same time an atom of B gains one electron. The molecular formula of the resulting compound is A_2B_2.	F	6	2
T:3:15:1	Most of the atomic volume is occupied by the nucleus.	F	23	17

Proposition Code	The Proposition	True/False	Number of Students Responding: Pretest	Posttest
T:3:15:2	Most of the atomic volume is occupied by the electrons.	T	15	32
T:3:15:3	Most of the atomic volume is occupied by the neutrons.	F	6	1
T:3:15:4	Most of the atomic volume is occupied by the positive charges.	F	5	2
T:3:16:1	The diameter of an atom is approximately 5×10^{-5}cm.	F	9	9
T:3:16:2	The diameter of an atom is approximately 5×10^{-8}cm.	T	22	28
T:3:16:3	The diameter of an atom is approximately 5×10^{-19}cm.	F	3	7
T:3:16:4	The diameter of an atom is approximately 5×10^{-24}cm.	F	16	9
T:3:17:1	The mass of a hydrogen atom is approximately 1.7×10^{-24}gm.	T	10	14
T:3:17:2	The mass of a hydrogen atom is approximately 1.7×10^{-19}gm.	F	7	24
T:3:17:3	The mass of a hydrogen atom is approximately 1.7×10^{-8}gm.	F	24	9
T:3:17:4	The mass of a hydrogen atom is approximately 1.7×10^{-5}gm.	F	7	3
T:3:18:1	Isotopes of a certain element are different from each other in their atomic number.	F	15	11
T:3:18:2	Isotopes of a certain element are different from each other in their atomic mass.	T	10	26

Proposition Code	The Proposition	True/False	Number of Students Responding: Pretest	Number of Students Responding: Posttest
T:3:18:3	Isotopes of a certain element are different from each other in their number of protons.	F	6	11
T:3:18:4	Isotopes of a certain element are different from each other in their number of electrons in the outside orbit.	F	21	5
T:3:19:1	Electrical charge of an electron and electrical charge on the proton are identical in value and sign.	F	3	4
T:3:19:2	Electrical charge of an electron and electrical charge on the proton are different from each other in value and sign.	F	19	8
T:3:19:3	Electrical charge of an electron and electrical charge on the proton are different from each other in value and identical to each other in sign.	F	14	5
T:3:19:4	Electrical charge of an electron and electrical charge on the proton are identical to each other in value and different from each other in sign.	T	15	35
T:3:20:1	The statement "Positively charged alpha particles collide with positively charged nucleus of the atom of the golden sheet, and they are reflected strongly" is more descriptive than explanatory.	F	7	28
T:3:20:2	The statement "The pressure of gas results from the movement and collision of small identical molecules which make the matter in a gaseous state" is more descriptive than explanatory.	F	13	9

Proposition Code	The Proposition	True/False	Number of Students Responding: Pretest	Number of Students Responding: Posttest
T:3:22:2	**The major scientific discovery resulting from firing alpha particles at a metallic sheet was electrons.**	F	10	3
T:3:22:3	**The major scientific discovery resulting from firing alpha particles at a metallic sheet was neutrons.**	F	13	7
T:3:22:4	**The major scientific discovery resulting from firing alpha particles at a metallic sheet was Dalton's theory.**	F	8	7

Fd

Alternative Propositions from Chapter I Tested Again at the End of Chapter III

Proposition Code	Proposition Code	The Proposition	True/False	Number of Students Responding f 1.1	f 1.2	f 3.2
T:3:23:1	T:1:1:1	Experiments conducted by scientists in their search for the structure of matter cannot be repeated except by scientists.	F	11	15	5
T:3:23:2	T:1:1:2	Experiments conducted by scientists in their search for the structure of matter can be repeated by anyone.	T	6	14	39
T:3:23:3	T:1:1:3	Experiments conducted by scientists in their search for the structure of matter did not provide evidence on the existence of atoms and molecules.	F	5	5	2
T:3:23:4	T:1:1:4	Experiments conducted by scientists in their search for the structure of matter proved that the molecule is the smallest part of matter.	F	29	19	7
T:3:24:1	T:1:2:1	When a scientist arrives at some conclusions depending on practical experiments, the conclusions are always correct.	F	2	1	7
T:3:24:2	T:1:2:2	When a scientist arrives at some conclusions depending on practical experiments, the conclusions are temporal and subject to change.	T	16	25	33
T:3:24:3	T:1:2:3	When a scientist arrives at some conclusions depending on practical experiments, the conclusions cannot be judged until other scientists also arrive at them.	F	32	15	8

Proposition Code	Proposition Code	The Proposition	True/False	Number of Students Responding f 1.1	f 1.2	f 3.2
T:3:24:4	T:1:2:4	When a scientist arrives at some conclusions depending on practical experiments, the conclusions are incorrect if prevailing theories cannot explain them.	F	3	12	5
T:3:25:1	T:1:24:1	If the mass of one mole of hydrogen is seven grams, then the number of moles of hydrogen molecules in 10 grams of hydrogen is 6.02×10^{23} moles.	F	2	1	3
T:3:25:2	T:1:24:2	If the mass of one mole of hydrogen is seven grams, then the number of moles of hydrogen molecules in 10 grams of hydrogen is $(2/10) \times 6.02 \times 10^{23}$ moles.	F	16	32	15
T:3:25:3	T:1:24:3	If the mass of one mole of hydrogen is seven grams, then the number of moles of hydrogen molecules in 10 grams of hydrogen is five moles.	T	28	13	32
T:3:25:4	T:1:24:4	If the mass of one mole of hydrogen is seven grams, then the number of moles of hydrogen molecules in 10 grams of hydrogen is two moles.	F	6	6	3

Proposition Code	Proposition Code	The Proposition	True/False	Number of Students Responding f 1.1	f 1.2	f 3.2
T:3:26:1	T:1:12:1	If the volume occupied by one mole of oxygen molecules at STP is 22.4 liters, then the volume occupied by one mole of hydrogen molecules is (2/32) x 22.4 liters.	F	9	3	6
T:3:26:2	T:1:12:2	If the volume occupied by one mole of oxygen molecules at STP is 22.4 liters, then the volume occupied by one mole of hydrogen molecules is (1/32) x 22.4 liters.	F	11	5	7
T:3:26:3	T:1:12:3	If the volume occupied by one mole of oxygen molecules at STP is 22.4 liters, then the volume occupied by one mole of hydrogen molecules is 22.4 liters.	T	22	35	31
T:3:26:4	T:1:12:4	If the volume occupied by one mole of oxygen molecules at STP is 22.4 liters, then the volume occupied by one mole of hydrogen molecules is (½) x 22.4 liters.	F	10	10	7
T:3:27:1	T:1:10:1	The statement "Equal volumes of different gases have the same number of molecules at similar conditions of pressure and temperature" is called Avogadro's hypothesis.	T	9	46	46
T:3:27:2	T:1:10:2	The statement "Equal volumes of different gases have the same number of molecules at similar conditions of pressure and temperature" is called Gay-Lusac law.	F	0	0	2

Proposition Code	Proposition Code	The Proposition	True/False	Number of Students Responding f 1.1	f 1.2	f 3.2
T:3:27:3	T:1:10:3	The statement "Equal volumes of different gases have the same number of molecules at similar conditions of pressure and temperature" is called general gas law.	F	26	1	2
T:3:27:4	T:1:10:4	The statement "Equal volumes of different gases have the same number of molecules at similar conditions of pressure and temperature" is called the law of definite proportion.	F	16	6	3
T:3:28:1	T:1:7:1	The mass of Avogadro's number of any chemical unit is called atomic weight.	F	21	4	6
T:3:28:2	T:1:7:2	The mass of Avogadro's number of any chemical unit is called atomic number.	F	10	1	5
T:3:28:3	T:1:7:3	The mass of Avogadro's number of any chemical unit is called atomic mass.	F	4	1	0
T:3:28:4	T:1:7:4	The mass of Avogadro's number of any chemical unit is called the mole.	T	18	47	41
T:3:29:1	T:1:8:1	If Avogadro's number is 6.02×10^{23} and the mass of a hydrogen mole is two grams, then the mass of one atom of hydrogen is 6.02×10^{23} grams.	F	9	3	6

Proposition Code	Proposition Code	The Proposition	True/False	Number of Students Responding f 1.1	f 1.2	f 3.2
T:3:29:2	T:1:8:2	If Avogadro's number is 6.02 x 10^{23} and the mass of a hydrogen mole is two grams, then the mass of one atom of hydrogen is (½) x 6.02 x 10^{23} grams.	F	11	5	9
T:3:29:3	T:1:8:3	If Avogadro's number is 6.02 x 10^{23} and the mass of a hydrogen mole is two grams, then the mass of one atom of hydrogen is (2/6.02) x 10^{23} grams.	F	16	15	15
T:3:29:4	T:1:8:4	If Avogadro's number is 6.02 x 10^{23} and the mass of a hydrogen mole is two grams, then the mass of one atom of hydrogen is (2/6.02) x 10^{-23} grams.	T	15	30	22
T:3:30:1	T:1:4:1	The relationship which describes the regular behavior of a natural phenomenon is called a fact.	F	10	2	4
T:3:30:2	T:1:4:2	The relationship which describes the regular behavior of a natural phenomenon is called a law.	T	21	44	34
T:3:30:3	T:1:4:3	The relationship which describes the regular behavior of a natural phenomenon is called a phenomenon.	F	14	3	8
T:3:30:4	T:1:4:4	The relationship which describes the regular behavior of a natural phenomenon is called a hypothesis.	F	8	3	7

Fe

Alternative Proposition from Chapter II
Tested Again at the End of Chapter III

Proposition Code	Proposition Code	The Proposition	True/False	Number of Students Responding f 1.1	Number of Students Responding f 1.2
T:3:31:1	T:2:17:1	If the mass of a mole of sugar is 342 grams and a liter of aqueous solution of sugar has 68.4 grams of sugar, then the molarity of this solution is 0.2 moles/liter.	T	14	14
T:3:31:2	T:2:17:2	If the mass of a mole of sugar is 342 grams and a liter of aqueous solution of sugar has 68.4 grams of sugar, then the molarity of this solution is 2.0 moles/liter.	F	14	20
T:3:31:3	T:2:17:3	If the mass of a mole of sugar is 342 grams and a liter of aqueous solution of sugar has 68.4 grams of sugar, then the molarity of this solution is 0.02 moles/liter.	F	17	15
T:3:31:4	T:2:17:4	If the mass of a mole of sugar is 342 grams and a liter of aqueous solution of sugar has 68.4 grams of sugar, then the molarity of this solution is 20.0 moles/liter.	F	8	3
T:3:32:1	T:2:18:1	If the mass of a mole of sugar is 342 grams, then the mass of sugar required to make a liter of solution with a 0.5 mole/liter concentration is 342 grams.	F	10	9
T:3:32:2	T:2:18:2	If the mass of a mole of sugar is 342 grams, then the mass of sugar required to make a liter of solution with a 0.5 mole/liter concentration is 684 grams.	F	8	5

Proposition Code	Proposition Code	The Proposition	True/False	Number of Students Responding f 1.1	f 1.2
T:3:32:3	T:2:18:3	If the mass of a mole of sugar is 342 grams, then the mass of sugar required to make a liter of solution with a 0.5 mole/liter concentration is 171 grams.	T	24	18
T:3:32:4	T:2:18:4	If the mass of a mole of sugar is 342 grams, then the mass of sugar required to make a liter of solution with a 0.5 mole/liter concentration is 0.5 grams.	F	9	19
T:3:33:1	T:2:19:1	If a mass of one mole of sugar is 342, then the volume of solution which is 0.01 M required to dissolve 3.42 grams of sugar is 10.0 liters.	F	5	9
T:3:33:2	T:2:19:2	If a mass of one mole of sugar is 342, then the volume of solution which is 0.01 M required to dissolve 3.42 grams of sugar is 1.0 liters.	T	10	17
T:3:33:3	T:2:19:3	If a mass of one mole of sugar is 342, then the volume of solution which is 0.01 M required to dissolve 3.42 grams of sugar is 0.1 liters.	F	17	10
T:3:33:4	T:2:19:4	If a mass of one mole of sugar is 342, then the volume of solution which is 0.01 M required to dissolve 3.42 grams of sugar is 0.01 liters.	F	19	16

APPENDIX G

FIAC MATRICES OF SEVEN DIFFERENT LESSONS

Lesson 1-4: Typical Lesson (1)
Lesson 2-4: Problem Solving and Review (2)
Lesson 2-8: Student Presentation
Lesson 3-2: Typical Lesson (3)
Lesson 3-3: Lab
Lesson 3-6: Read Aloud from the Textbook
Lesson 3-7: Problem Solving and Review (1)

FIAC Matrix of Lesson 1-4
Typical Lesson (1)

	1	2	3	4	5	6	7	8	9	10	TOT	%
1											0	0
2					1						1	0.11
3			48	21	35	1		4	1	7	117	13.28
4				38	2	1		59		26	126	14.30
5				41	351	1		3	2	26	424	48.13
6						6		1		7	14	1.59
7				1			6	1		1	9	1.02
8		1	60	8	6		1	18		1	95	10.78
9			3		1				3	1	8	0.91
10			6	17	28	5	2	9	2	18	87	9.88
TOT	0	1	117	126	424	14	9	95	8	87	881	100.0
%	0	0.11	13.28	14.30	48.13	1.59	1.02	10.78	0.91	9.88	100.0	

← 78.43% → ← 11.69% → 9.88%

FIAC Matrix of Lesson 2 - 4
Review-Problem Solving (2)

	1	2	3	4	5	6	7	8	9	10	TOT	%
1											0	0
2		1		1			1		1		4	0.62
3			16	10	6	4			3	1	40	6.15
4				24	4	2		21	2	3	96	8.62
5				9	178	6			5	5	203	31.23
6		1	2	5	5	70	2		4	23	112	17.23
7				1		4	13	1		5	24	3.69
8			14	2	2	3	2	11		2	36	5.54
9		2	5	1	1	3			13	6	31	4.77
10			3	3	7	20	6	3	3	99	144	22.15
TOT	0	4	40	56	203	112	24	36	31	144	650	100
%	0	0.62	6.15	8.62	31.23	17.23	3.69	5.54	4.77	22.15	100	

← 67.54% → ← 10.30% → 22.15

FIAC Matrix of Lesson 2 - 8
Students' Presentation

	1	2	3	4	5	6	7	8	9	10	TOT	%
1						2				2	4	0.48
2				1							1	0.12
3			41	13	25				4	10	93	11.15
4	2			29	1	4	2	42		13	93	11.15
5		1		25	321	2			6	46	401	48.08
6			1	1	2	6	1	4	4	2	21	2.52
7				1		2	4				7	0.84
8			39	6	1			10		5	61	7.31
9			5	7		1			28	4	45	5.40
10	2		7	10	51	4		5	3	26	108	12.90
TOT	4	1	93	93	401	21	7	61	45	108	834	100
%	0.48	0.12	11.15	11.15	48.08	7.52	0.84	7.31	5.40	12.90	100	

← 74.34% → ← 12.71% → 12.90

FIAC Matrix of Lesson 3 - 2
Typical Lesson (3)

	1	2	3	4	5	6	7	8	9	10	TOT	%
1	1									1	2	0.25
2				1	1						2	0.25
3	1		15				1	37	1		55	7.01
4		1	10	29	32	1	2	2		1	78	9.95
5			30	2	517	1	2	1		1	554	70.7
6					1	15	1			1	18	2.3
7					1		7	2		3	13	1.66
8				41				4		4	49	6.25
9					1						1	0.13
10		1		5	1	1		3		1	12	1.53
TOT	2	2	55	78	554	18	13	49	1	12	784	100
%	0.25	0.25	7.01	9.95	70.7	2.3	1.66	6.25	0.13	1.53	100	

← 92.09 → ← 6.38% → 1.53

FIAC Matrix of Lesson 3 - 3
(The Lab)

	1	2	3	4	5	6	7	8	9	10	TOT	%
1					1					4	5	0.60
2											0	0
3			14	4	9	1			1	11	40	4.80
4				10		2		18	1	3	34	4.07
5				9	391	5			4	45	454	54.57
6	2		1	4		23	1	1		7	39	4.67
7				1	1		2				4	0.48
8			18	1		1		1			21	2.51
9			2				1		2	7	12	1.44
10	3		5	5	52	7		1	4	149	226	27.07
TOT	5	0	40	34	454	39	4	21	12	226	835	100
%	0.60	0	4.80	4.07	54.37	4.67	0.48	2.51	1.44	27.07	100	

← 68.98% → ← 3.95 → 27.07

FIAC Matrix of Lesson 3-6
Read Aloud from the Textbook

	1	2	3	4	5	6	7	8	9	10	TOT	%
1											0	0.0
2											0	0.0
3			17	2	14	1			1	1	37	5.15
4				1		1		10		1	13	1.8
5			1	5	328	11		2	2	3	352	48.96
6			1	2	5	6	1	17		2	34	47.36
7								1			1	0.14
8			15	2	5	9		224	4		259	36.02
9			3			1		3	7	1	15	2.09
10						5		2	1		8	1.11
TOT	0	0	37	13	352	34	1	259	15	8	719	100.0
%	0.0	0.0	5.15	1.8	48.96	4.73	0.14	36.02	2.09	1.11	100.0	

← 60.78% → | ← 38.11% → 1.11%

FIAC Matrix of Lesson 3-7
Review-Problem Solving (1)

	1	2	3	4	5	6	7	8	9	10	TOT	%
1	1		1			1		1	1		5	1.07
2											0	0.0
3	2		18	10	15	1			2	2	50	10.73
4				28	3	2	3	30		2	68	14.60
5				19	171	3			2	13	208	44.69
6	1			2	4	4	1	3		4	19	4.08
7				2		1	7		1	2	13	2.79
8			26	2	3	1		12		2	46	9.87
9			5	2		4			7		18	3.86
10	1			3	12	2	2		5	14	39	8.37
TOT	5	0	50	68	208	19	13	46	18	39	466	100.0
%	1.07	0.0	10.73	14.60	44.64	4.08	2.79	9.87	3.86	8.37	100.0	

|← 77.90% →|← 13.73 →| 8.37

APPENDIX H

THE GARBAGE COLLECTOR ANALOGY

THE GARBAGE COLLECTOR ANALOGY*

A new tenant is told by his neighbor that the garbage collector comes every Thursday, early in the morning. later, in answer to a question from his wife about the same matter, the tenant says, "I have been told there is a garbage collector and that he comes early Thursday morning. We shall see if this is true." The tenant, a scientist, accepts the statement of the neighbor (who has had opportunity to make observations on the subject). However, he accepts it tentatively until he himself knows the evidence for the conclusion.

After a few weeks, the new tenant has made a number of observations consistent with the existence of a Thursday garbage collector. Most important, the garbage does disappear every Thursday morning. Second, he receives a bill from the city once a month for municipal services. And there are several supplementary observations that are consistent--often he is awakened at 5:00 am on Thrusdays by a loud banging and sounds of a truck. Occasionally, the banging is accompanied by a gay whistling, sometimes by a dog's bark.

The tenant now has many reasons to believe in the existence of the garbage collector. Yet he has never seen him. Being a curious man and a scientist, he sets him alarm clock one Wednesday night to ring at 5:00 am. Looking out the window Thursday morning, his first observation is that it is surprisingly dark out and things are difficult to see. Nevertheless, he discerns a shadowy form pass by, a form that looks like a man carrying a large object.

Seeing is believing! But which of these pieces of evidence really constitutes "seeing" the garbage collector? Which piece of evidence is the basis for "believing" there is a garbage collector? The answer is, all of the evidence taken together constitutes "seeing." And all of the evidence taken together furnishes the basis for accepting the "garbage collector theory of garbage disappearance." The direct vision of a shadowy form at 5:00 am would not constitute "seeing a garbage collector" if the garbage didn't disappear at that time. (The form might have been a paper boy or the milkman.) Neither would the garbage disappearance alone consist of "seeing" the garbage collector. (Perhaps a dog comes by every Thursday and eats the garbage. Remember, a dog's bark was heard!) No, the tenant is convinced there is a garbage collector because the assumption is consistent with so many observations, and it is inconsistent with none. Other possible explanations fit the observations too, but not as well (the tenant has never heard a dog whistle daily). The garbage collector theory passes the test of a good theory--it is useful in explaining a large number of experiemntal observations. This was true even before the tenant set eyes on the shadowy form at 5:00 am.

Yet we must agree, there are advantages to the "direct vision" type of experiment. Often more detailed information can be obtained this way. Is the garbage collector tall? Does he have a mustache? Could the garbage collector be a woman? This type of information is less easily obtained from other methods of observation. It is worthwhile setting the alarm clock, even after we have become convinced there is a garbage collector.

---

*CHEM-Study: Chemistry: An Experimental Science (student textbook), 1965.

At the beginning of this course, you were a new tenant. You were told that chemists believe in atoms and you were asked to accept this proposal tentatively until you yourself knew the evidence for it. Sicne that time, we have used the atomic theory continuously in our discussions of chemical phenomena. The atomic theory passes the test of a good theory: it is useful in explaining a large number of experimental observations. We have become convinced there are atoms.

APPENDIX I

A QUESTIONNAIRE FOR SCIENCE SUPERVISORS

A QUESTIONNAIRE FOR SCIENCE SUPERVISORS

In the name of God, most gracious, most merciful

Dear science supervisor at ________________,

Peace and blessings be upon you

In order to prepare for a study about science teaching and learning in Jordan, I would like you kindly to answer the following questions. Thank you for your cooperation.

Sincerely yours,

Fathi Malkawi

---

1. Name three major problems relevant to teaching and learning natural science program for students of the tenth grade.

2. Name three topics you feel teachers of this program find difficulty in teaching them.

3. Choose the best six teachers (three males and three females) of this program in your district and provide the following information:

Teachers' names and addresses	Schools' names and addresses	Reasons for choosing teacher among the best

APPENDIX J

A QUESTIONNAIRE FOR TEACHERS WHO ARE CANDIDATES TO PARTICIPATE IN THE STUDY

A QUESTIONNAIRE FOR TEACHERS WHO ARE CANDIDATES
TO PARTICIPATE IN THE STUDY

In the name of God, most gracious, most merciful

Dear science teacher of natural science program at ______________

Peace and blessings be upon you

I have the pleasure to inform you that you have been selected to be among the best teachers of the natural science program for students of the tenth grade. You are now a candidate to participate in a study about teaching and learning science in Jordan. To prepare for this study, please answer the following questions. Thank you for your cooperation.

Sincerely yours,

Fathi Malkawi

---

1. Your name and address

2. Your educational qualifications

3. Years of service in teaching

4. Years of teaching the natural science program for tenth grade

5. Training courses you attended relevant to this program, including course name, place, date, authority who organized the course, and duration of course.

6. Name three problems you face in teaching the natural science course.

7. Name three topics you found most difficult to teach.

8. Do you use other references besides the textbook? If so, name them.

9. Do you use the teachers' guide for this program? (Circle YES or NO.) If yes, aspects of the teachers' guide you found useful.

Aspects of the teachers' guide you found not useful.

Your suggestions to improve the teachers' guide.

10. Do you use a special notebook plan prepared for teaching the natural science program? If yes, what are the elements of your planning? If no, why not?

11. Would you like to participate in a study aobut teaching and learning science in Jordan? If yes, why? If no, why not?

APPENDIX K

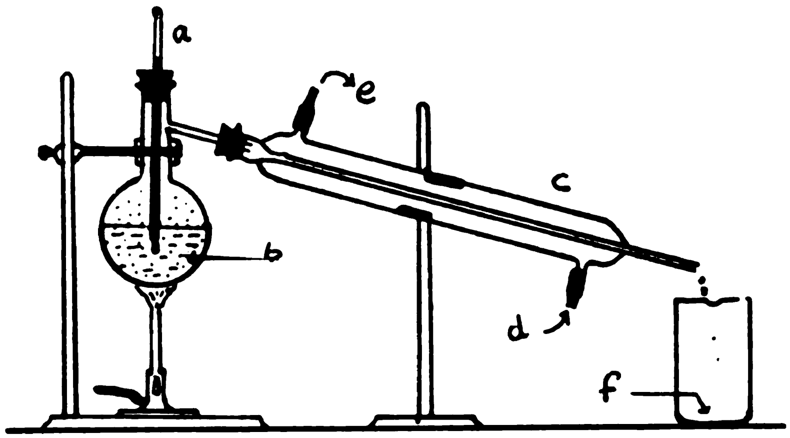
PAGE 36 OF THE NSC TEXTBOOK

APPENDIX

PAGE 36 OF THE NSC TEXTBOOK

* 2:3:1 Behavior of the solution during heating

Heat a solution of sugar in water until it boils. Condense the vapor which is formed, using distillation apparatus as in Figure 2.3.



a: thermometer
b: solution of sugar in water
c: condenser
d: cold water inlet
e: water outlet
f: pure water

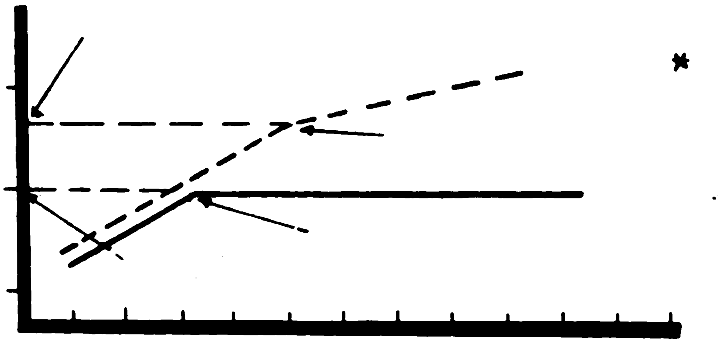
Figure 2.3. Simple distillation apparatus.

Notice the behavior of the solution during boiling.

* Does the solution boil at the same temperature as the boiling point of pure water?

* Does the temperature stay constant during boiling as it does during boiling pure water? Or does the temperature continue to rise?

Compare the behavior of pure water and that of the solution as represented in figure 2.4. Try to recognize the nature of the pointsreferred to by arrows.



*

____ pure water

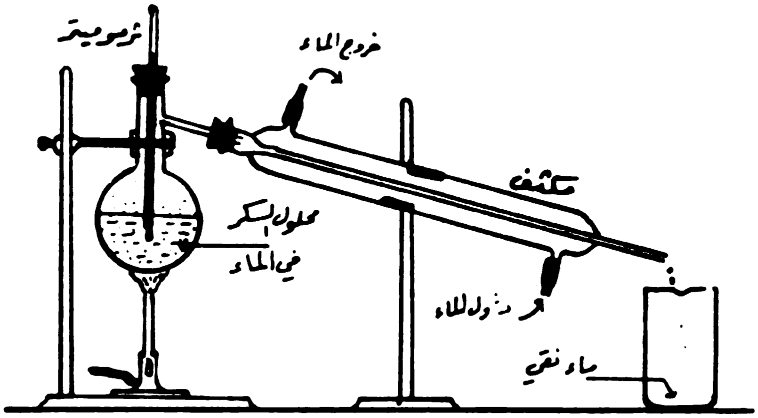
---- solution

Figure 2.4. Behavior on boiling.

* printed in blue

١:٣:٢ سلوك المحلول اثناء التسخين :

سخن محلولا من السكر في الماء حتى الغليان ، وكثف البخار الناتج مستخدما جهاز تقطير كما في الشكل (٢-٣) .



(شكل ٢-٣)

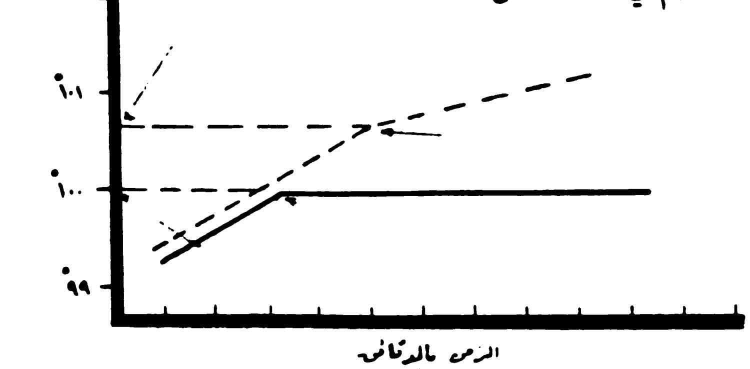
ولاحظ كيف يسلك المحلول اثناء الغليان .

هل يغلي المحلول في نفس درجة غليان الماء النقي ؟

هل تثبت درجة الحرارة اثناء الغليان كما يحصل عند غليان الماء النقي ام تستمر في الارتفاع ؟

قارن بين سلوك الماء النقي وسلوك المحلول في الشكل (٢ - ٤)

وحاول التعرف على طبيعة النقاط التي تشير اليها الاسهم في هذا الشكل .



(شكل ٢-٤)

APPENDIX L

PLAN FOR LESSON 3.2

COURSE: NCS | CLASSROOM: 1st Sec (1) | DAY: Tuesday

TOPIC: Expanding the atomic model | PERIOD: 2nd | DATE: March 2nd

---

GENERAL GOAL OF THE COURSE: To acquire fundamental information which is required to understand and interpret natural phenomena, to understand the nature of science, to develop scientific attitudes and mental and sensory skills.

SPECIFIC OBJECTIVES OF THE LESSON: (1) student should know that matter has an electrical nature, and know the relationship between matter and electricity; (2) to understand experiments of electrolysis (Faraday's laws); (3)

ACTIVITIES, AIDS, AND TECHNIQUES:

1. Conduct some simple experiments which form static electricity.
2. Demonstrate an electrical battery and recognize its components.
3. Explain Faraday's two laws and illustrate them.
4. Conduct the experiment of electrolysis, if possible.

EVALUATION: If 96500 coulum have been able to precipitate the garamic atomic weight of silver 108 gm, then what is the charge of one particle?

COMMENTS: Repeat the same lesson for section 1.2

We were not able to finish Faraday's second law.

المبحث: العلوم الطبيعية **الصف:** الاول الثانوي ب ١١ **اليوم:** الثلاثاء

الموضوع: توسيع النموذج الذري **الحصة:** الثامنة **التاريخ:** ٢/٣/٨٤

الهدف العام للمبحث: اكتساب المعلومات الاساسية اللازمة لفهم وتفسير الظواهر الطبيعية لفهم طبيعة العلم وتنمية الاتجاهات العلمية والمهارات العقلية والحسية المختلفة .

الاهداف الخاصة للحصة: ١- ان تعرف الطالبة ان المادة ذات طبيعة كهربائية وتعرف العلاقة بين المادة والكهرباء .

٢- فهم تجارب التحليل الكهربائي (قوانين فرادي)

٣-

الانشطة والوسائل والأساليب: ١- عمل بعض التجارب البسيطة التي تحدث الكهرباء الساكنة

٢- عرض نظرية كهربائية والتعرف على مكوناتها .

٣- شرح قانوني فارادي وتوضيحها

٤- عمل تجربة تحليل كهربائي ان امكن .

التقويم: اذا رسبت ٩٦٥٠٠ كولوم الوزن الذري الغرامي للفضة ١٠٨ غم ماهي شحنة الفضة الواحدة ؟

الملاحظات: تعاد نفس الحصة لشعبة ١٠٢ .

لم نستطيع اعطاء القانون الثاني لفرادي

APPENDIX M

PLAN FOR LESSON 3.6

COURSE: NCS	CLASSROOM: 1st Sec (1)	DAY: Tuesday
TOPIC: Expanding the atomic model	PERIOD: 2nd	DATE: March 9th

GENERAL GOAL OF THE COURSE:

SPECIFIC OBJECTIVES OF THE LESSON: (1) to understand and be able to explain electrification and electrical conductivity and (2) the student should know Van Der Waal forces.

ACTIVITIES, AIDS, AND TECHNIQUES:

1. Student will read aloud, then comments on some points will be provided.

EVALUATION:

COMMENTS: Wednesday, March 10, is the school activities day.

المبحث: العلوم الطبيعية **الصف:** الاول الثانوي **اليوم:** الثلاثاء

الموضوع: توضيح النموذج الذري **الحصة:** الثانية **التاريخ:** ٩/٢/٢

الهدف العام للمبحث:

الاهداف الخاصة للحصة: ١- ان تفهم وان تستطيع تفسير كل من عدم التكهرب والتوصيل الكهربائي.

٢- ان تعرف الطالبة ما هي قوى فان ديرفال.

الانشطة والوسائل والأساليب: ١- ان تقرأ احدى الطالبات بصوت عالي ثم التعليق على بعض النقاط.

التقويـم:

الملاحظات: الاربعاء ١٠/٢ نشاط

APPENDIX N

MISS TALIB'S RESPONSE TO QUESTIONNAIRE FOR TEACHERS WHO ARE CANDIDATES TO PARTICIPATE IN THE STUDY

A QUESTIONNAIRE FOR TEACHERS WHO ARE CANDIDATES TO PARTICIPATE IN THE STUDY

In the name of God, most gracious, most merciful

Dear science teacher of natural science program at ____________

Peace and blessings be upon you

I have the pleasure to inform you that you have been selected to be among the best teachers of the natural science program for students of the tenth grade. You are now a candidate to participate in a study about teaching and learning science in Jordan. To prepare for this study, please answer the following questions. Thank you for your cooperation.

Sincerely yours,

Fathi Malkawi

---

1. Your name and address

2. Your educational qualifications
   B.Sc. (Chemistry) + Diploma (Ed.)

3. Years of service in teaching
   Three years

4. Years of teaching the natural science program for tenth grade
   The second year

5. Training courses you attended relevant to this program, including course name, place, date, authority who organized the course, and duration of course.

6. Name three problems you face in teaching the natural science course.

   Large number of students in each classroom
   The lack of prior experiences for some students
   The large size of the required subject matter

7. Name three topics you found most difficult to teach.

    I have not faced any problem in teaching the subject matter of natural science course so far.

8. Do you use other references besides the textbook? If so, name them.

    No

9. Do you use the teachers' guide for this program? (Circle YES or NO.) If yes, aspects of the teachers' guide you found useful.

    No

    Aspects of the teachers' guide you found not useful.

    Your suggestions to improve the teachers' guide.

10. Do you use a special notebook plan prepared for teaching the natural science program? If yes, what are the elements of your planning? If no, why not?

    Yes. Elements of lesson plan:
    objectives
    activities, techniques and aids
    evaluation

11. Would you like to participate in a study aobut teaching and learning science in Jordan? If yes, why? If no, why not?

    Yes. To make use of the experiences of others and to develop my abilities and skills in teaching.

بسم الله الرحمن الرحيم

الاخ/الاخت معلم العلوم الطبيعية للصف الاول الثانوي في مدرسة .

السلام عليكم ورحمة الله وبركاته وبعد،

يسرني ان اخبرك بانه قد وقع عليك الاختيار لتكون ضمن افضل معلمي العلوم الطبيعية للصف الاول الثانوي في المملكة ، واصبحت بذلك مرشحا للاشتراك في دراسة علمية بخصوص واقع تدريس العلوم في الاردن . وللتمهيد لهذه الدراسة ، ارجو التكرم بالاجابة على الاسئلة التالية ، مع وافر الشكر والتقدير

المخلص : فتحي حسن ملكاوي

---

١. الاسم (ثلاثي)

٢. المؤهل العلمي .. بكالوريوس كيمياء ... دبلوم التربية ..

٣. عدد سنوات الخدمة في التعليم ... ثلاث سنوات ....

٤. عدد سنوات تعليم العلوم الطبيعية ..... السنة الثانية ....

٥. الدورات التي حضرتها بخصوص تدريس العلوم الطبيعية للاول الثانوي

الدورة : مكانها :

مدتها : تاريخها :

٦. المشكلات التي تعاني منها في تدريس العلوم الطبيعية للاول الثانوي

أ ـ كثرة عدد الطالبات في الشعبة الواحدة

ب ـ نقص في الخبرات السابقة لدى بعض الطالبات

ـ كثافة المادة الدراسية .

٧. اهم ثلاث موضوعات التي تجد صعوبة في تدريسها ضمن مادة العلوم الطبيعية للاول الثانوي

أ ـ ليس هناك اي موضوع اجد صعوبة في تدريسه ضمن

ب ـ مادة العلوم الطبيعية حتى الآن .

ج ـ

٨. هل تستعمل مراجع اخرى بالاضافة الى الكتاب المقرر؟ لا

اذكر اسماء المراجع : ١.

٢.

٣.

٩. هل تستعمل كتاب دليل المعلم ؟ لا

ما هي الجوانب التي استفدتها من هذا الكتاب؟

ما هي الجوانب التي لم تجدها مفيدة ؟

ما هي مقترحاتك لتحسين دليل المعلم؟

١٠. هل تستعمل دفتر تحضير لتدريس مادة العلوم الطبيعية ؟ نعم

اذا كان الجواب ايجابيا ما هي عناصر الخطة الدراسية التي تستعملها ؟

عناصر الخطة الدراسية

الاهداف

الانشطة ، الاسلوب ، الوسائل

التقويم .

اذا كان الجواب سلبيا ، لماذا ؟

١١. هل ترغب في الاشتراك في دراسة علمية لواقع تدريس العلوم في الاردن؟

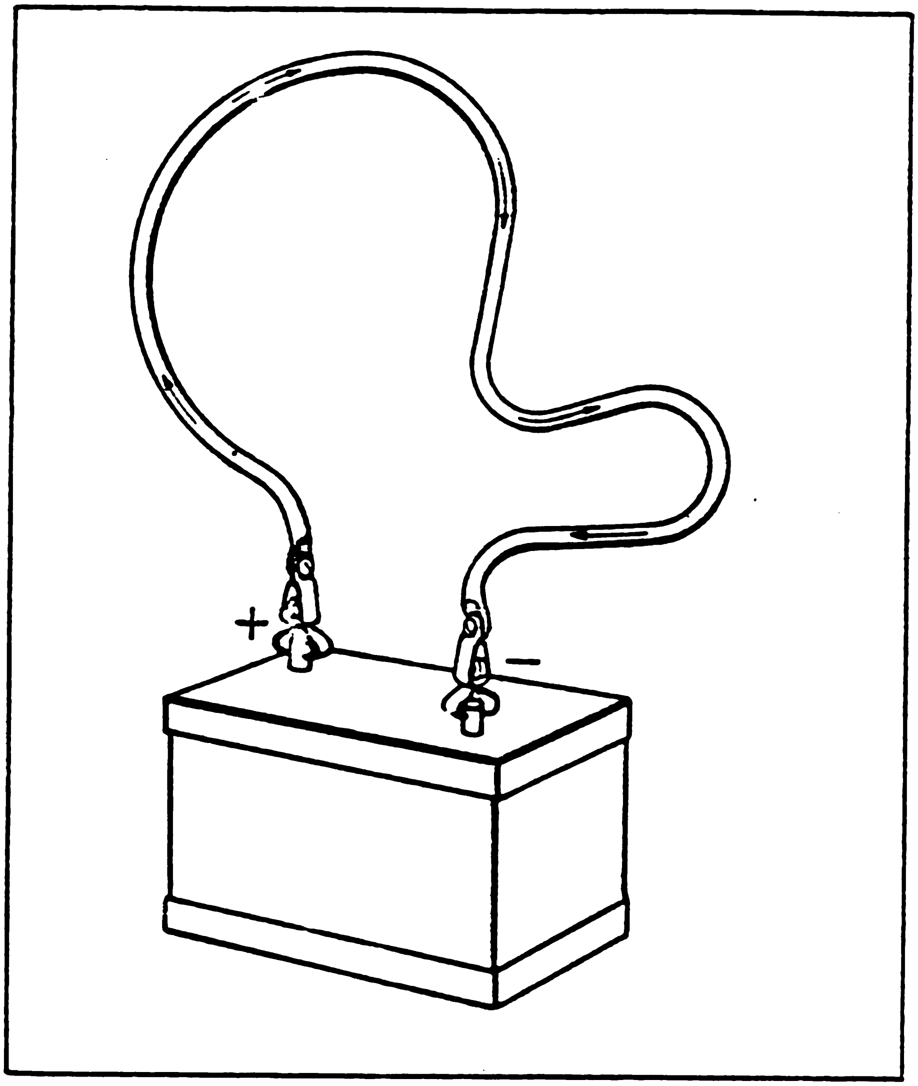
✓ نعم لماذا ؟

لا لماذا؟

نعم وذلك للاستفاده من خبرات الاخرين وتنمية قدراتي ومهاراتي في التدريس .

APPENDIX O

A DIAGRAM TAKEN FROM THE NSF-SPONSORED PHYSICS PROJECT (PSSC)



29–20. When a conductor is connected to a battery, there is an electric field inside the wire that runs from the positive to the negative battery terminal.

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