

THE IMPACT OF TEACHING CHEMISTRY BY "INSTRUCTIONAL FUNCTIONS
APPROACH" ON STUDENT ACHIEVEMENT: AN EXPERIMENTAL
STUDY OF GRADE ELEVEN

BY
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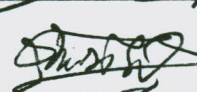
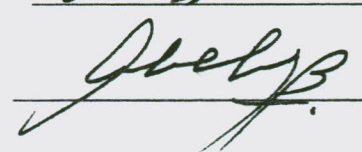
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TABLE OF CONTENTS

Acknowledgements

Table of contents

List of tables

List of appendices

Abstract

Chapter One ... 1

1. Introduction ... 1

1.1 Background of the Study ... 1

1.2 Statement of the problem ... 2

1.3 Significance of the Study ... 3

1.4 The instructional Functions Approach Model ... 3

1.5 Specific Objectives of the Study ... 4

1.6 Delimitation of the Study ... 4

1.7 Data Collection Tools ... 5

1.8 Limitations of the Study ... 5

1.9 Definition of Terms ... 6

Chapter Two ... 7

2. Review of Related Research and Literature ... 7

2.1 An Overview of Effective Instruction ... 7

2.2 Synthesis of Research on the Various Instructional
Functions ... 12

2.3 Summary of Findings on the Instructional Functions
Approach ... 29

Chapter Three ... 33

3. Design and Procedures of the Study ... 33

3.1 Null Hypotheses ... 34

3.2 Selection of Subjects ... 35

3.3 Procedures ... 36

3.4 Validity and/or Reliability of the Instruments ... 38

Chapter Four ... 42

4. Report and Analysis of Findings ... 42

4.1 Test for the Proportion of Implementation of
Instructional Functions ... 42

4.2 Test for the Adjusted Population Means of Student
Achievement ... 47

4.3 Test for a Population Correlation Coefficient Between
Content Coverage and Student Achievement ... 52

4.4 Test for Population Partial and Part Correlation
Coefficients among Fact Test, Comprehension Test
and Content Coverage ... 54

Chapter Five ... 57

5. Summary, Conclusions and Recommendations ... 57

5.1 Summary ... 57

5.2 Conclusions ... 59

5.3 Recommendations ... 60

List of Tables

Table 1.	Modifications to suit different students ...	31
2.	Reliability coefficients (r) for items of the checklist ...	41
3.	Proportions of instructional behaviours in percent and their Z-values for the various groups ...	43
4.	Data for ANCOVA ...	48
5.	Summary ANCOVA ...	49
6.	Summary of Q using the TK procedure ...	51
7.	Means (standard deviations), correlation coefficients and t-values for content coverage and achievement..	54
8.	Means (standard deviations) and correlation coefficients for content coverage, fact and comprehension test achievement ...	55
9.	Summary of key instructional behaviours ...	66
10.	Aspects of clear presentation ...	69

List of Figures

Figure 1.	Elements of Direct Instruction ...	11
2.	Reaction Rates and Their Variation in Time for a General Reaction of the Type $A + B \rightleftharpoons C + D$...	85

List of Appendices

Appendix I.	A Manual of Methods and Techniques Needed to Implement the Six Instructional Functions by 11th Grade Experimental Chemistry Teachers ...	65
II.	A Checklist for Coding Implementation of Instructional Behaviours ...	79
III.	The Grid (Test Specification) ...	83
IV.	Chemistry Test for Grade 11 ...	85

Abstract

In this study, an attempt was made to investigate the impact of a chemistry teaching program by "Instructional Functions Approach" on student achievement. The study employed the "pre test - post test control group experimental design" in which case the treatment teachers received training in the use of the instructional functions approach model.

The subjects consisted of 24 11th grade chemistry teachers randomly selected from 8 senior secondary schools in Addis Ababa. The students (1735) of these teachers were tested at the beginning and end of the project.

The results of this experimental study suggest that the treatment was generally effective in the sense that when the instructional treatment is implemented, it has a positive impact on student achievement.

CHAPTER ONE

1. INTRODUCTION

In this chapter an attempt is made to briefly describe the problem or the study taking into consideration its: background, significance, specific objectives and scope. Mention is also made about the general model employed in the study and the data collection instruments. Limitations of the study and definition of terms are also included.

1.1 Background of the Study

The writer of this paper inspected, in the year 1990/91, the Ethiopian Senior Secondary School Chemistry Text Books and Curriculum Guides and found that:

- (1) all the five text books are full of facts, concepts, rules and/or generalizations;
- (2) knowledge and comprehension (39% and 30%, respectively) are the cognitive behaviours most commonly demanded of the student by the activities of the chemistry program;
- (3) knowledge and comprehension (53% and 25%, respectively) are the cognitive behaviours most commonly demanded of the student by the objectives of the program.

He then felt that such contents can effectively be taught and such objectives can effectively be achieved by treating the subject in the form of explicit teaching or by instructional functions approach. Rosenshine and Stevens also argue that:

These explicit teaching procedures are most applicable in those areas where the objective is to master a body of knowledge or learn a skill which can be taught in a step-by-step manner. Thus, these procedures apply to the teaching of facts that students are expected to master so that they can be used with new information in the future...

Similarly, the procedures apply to the teaching of processes or skills that students are expected to apply to new problems or situations (1986: 377).

1.2 Statement of the Problem

It seems obvious that teachers vary in their effectiveness while they are dealing with the same subject matter of a certain school system. Dunkin and Biddle expressed their opinions about this variations in the following words: " ... If teachers vary in their effectiveness, then it must be because they vary in the behaviours they exhibit in the classroom. To shed light on this point one must study the classrooms--- where the action actually is " (1974: 13).

It is also argued that the teacher's ability to cause pupils to learn what they are supposed to learn is a direct indicator of his/her effectiveness. In other words, teacher effectiveness and pupil achievement are directly proportional to each other. " Yet the early studies of teacher effectiveness seldom employed pupil learning as a criterion" (Ibid.: 14). This is, in the

1.4 The Instructional Functions Approach Model

The details of the instructional functions are presented in Appendix I.

1. Review, check previous day's work (and reteach, if necessary).
2. Present new content/skills.
3. Guide student practice (and check for understanding).
4. Feedback and correctives (and reteach, if necessary).
5. Independent student practice.
6. Weekly and monthly reviews (Rosenshine and Stevens: 379).

1.5 Specific Objectives of the Study

1. To determine whether explicit teaching or step-by-step teaching can contribute to the effectiveness of chemistry teaching in Addis Ababa Senior Secondary School conditions.
2. To select those teachers or instructional functions which contribute highly to student achievement and thereby recommend these functions as instructional guidelines for our chemistry teachers.
3. To determine the extent to which teachers coverage of the existing chemistry syllabus content contributes to student achievement.

1.6 Delimitation of the Study

The scope of the study was confined to randomly selected eleventh-grade chemistry classrooms of Addis Ababa. The classrooms were selected from both government and non government schools: some of the reasons that forced the researcher to select 11th grade classrooms as the focus of his study were:

1. since the number periods for chemistry in grades 9 and 10 is few (two periods per week for each grade), it might be difficult to apply step-by-step teaching in these grade levels and since grade 12 students might complete their study before the research work is over and since it is felt that the classroom situation at this grade level might be different from others---at least for the reason that the students are preparing themselves for the ESLCE---this grade was made out of the focus of the study.
2. since streaming into science and social studies begin at grade 11, the selected eleventh-grade students were science students in general, and were attending chemistry lessons during the time of observation, in particular.

1.7 Data Collection Tools

The study was primarily experimental in nature. Consequently, various instruments were used to collect data relevant to the problem.

These instruments were:

- pre-test and post-test administered to 11th grade students
- a checklist used to code the instructional behaviours recorded using the audio-tape.

1.8 Limitation of the Study

Since there was a problem of changing the schedule of the regular classrooms, the study did not include grades 9, 10 and 12, in which case the study would have been more comprehensive than it was.

It is also felt that the use of a video-tape rather than an audio-tape would have improved the quality of the research to some extent.

Due to scarcity of computer programs employed in this study in the university, the researcher used a pocket calculator in which case the accuracy of calculations might not be as it is in the computer programs.

Finally, the scarcity of professionals both in the subject matter of chemistry and the teaching of chemistry could be a problem of reliability among coders while coding the instructional behaviours recorded by the audio-tape.

1.9 Definition of Terms

For most of the terms included in this study, a glossary is found in Appendix I. Besides, the following term is defined.

Instructional Functions Approach--- refers to the small-step approach using the six functions included in the model (see 1.4). It is interchangeably used with the following terms: direct instruction, explicit instruction, step-by- step instruction, systematic teaching, active teaching and effective teaching.

CHAPTER TWO

2. REVIEW OF RELATED RESEARCH AND LITERATURE

This chapter focuses on reviewing research findings and literature deemed relevant to the present study. The contents of the chapter are divided into three topics presented in the following order: (1) an overview of effective instruction, (2) synthesis of research on the various instructional functions, and (3) summary of findings on instructional functions approach.

2.1. An Overview of Effective Instruction

The topic focuses on laying a conceptual framework of 'teacher effectiveness' and the 'instructional functions approach'.

2.1.1. Conceptualization of Teacher Effectiveness

Until recently, there can be no doubt that the teacher has been examined as to who he is and what he does, but to a minor degree as to what he produces. In other words, the earlier researches on teacher's personal traits led to presage rather than process-product studies (Brophy and Good, 1986; Galton and Eggleston, 1979; Schofield and Start, 1979/80). Although the former approach produced some consensus on virtues considered desirable in teachers -- such as qualification, appearance, intelligence, etc. -- it failed to produce any information on

linkages between specific teacher behaviour (process variables) and student achievement (product variables).

From the above discussions, it is apparent that there couldn't be consensus on what constitutes the operational definition of teacher effectiveness in process-product research programs.

After taking into consideration the problems associated with outcome measurement, it is claimed that the standard conceptualization of teacher effectiveness in process-product research has the following properties (Shavelson et al., 1986:52):

1. Effectiveness assumes commonality of curriculum goals, objectives, and content coverage across classrooms because one standard achievement test is used to judge the effectiveness [of instructions] in all classrooms.
2. Effectiveness is strictly summative in its measurement of subject matter knowledge. It is not what students know or don't know that matters, but the accumulated quantity of their knowledge in comparison with students in other classrooms.
3. Performance on the effectiveness measure is equated with [subject matter] knowledge or skill in subject matter. There is no notion of "less than best effort", guessing, partial knowledge, or test-taking skill.
4. Effectiveness is strictly aggregative across students within a classroom. Operationally, regardless of how student performance is distributed within the classroom,

the class average is chosen to represent class performance.

In particular cases, researchers have tried to compare the gains of those students taught with structured curricula and those taught with more individualized approaches, or who receive their instruction directly from the teacher and those who are expected to learn new material on their own or from each other. Rosenshine's review of such correlational and experimental researches helped pull together the following conclusions: Thus, from correlational and experimental studies, we find

- (a) a general pattern of effective instruction;
- (b) an advantage to direct, explicit instruction...;
- and
- (c) the importance of over learning, particularly for hierarchically organized material (1983:337).

2.1.2. The Concept of Instructional Functions Approach.

Based on the above conclusive remarks, Rosenshine and Stevens (1986) developed a general model of effective instruction which they named the "Instructional Functions" approach.

In the language of Bellon et al. (1992), Corno and Snow (1986), Fielding et al. (1983), and Good (1979), the model is widely known as a "Direct Instruction" approach. Hence the two names are hereafter interchangeable. The model is, therefore, presented and discussed in the ensuing pages.

The Instructional Functions Approach Model¹

The model consisted of the following six fundamental instructional functions:

1. Review, check previous day's work (and reteach, if necessary).
2. Present new content/skills.
3. Guide student practice (and check for understanding)
4. Feedback and correctives (and reteach, if necessary).
5. Independent student practice.
6. Weekly and monthly reviews (Rosenshine and Stevens:379).

As can be seen from the model, the sequence of instruction recognizes the importance of the teacher. According to both Lehr and Baumann, a good working definition for instructional functions approach is explicit instruction with an academic focus led by teachers who interact directly with their students (Bellon et al.: 237).

The approach also represents an "... effort by the teacher to monitor and control student classroom attention and persistence..., rather than to permit or encourage students to control their own behaviour" (Corno and Snow: 622).

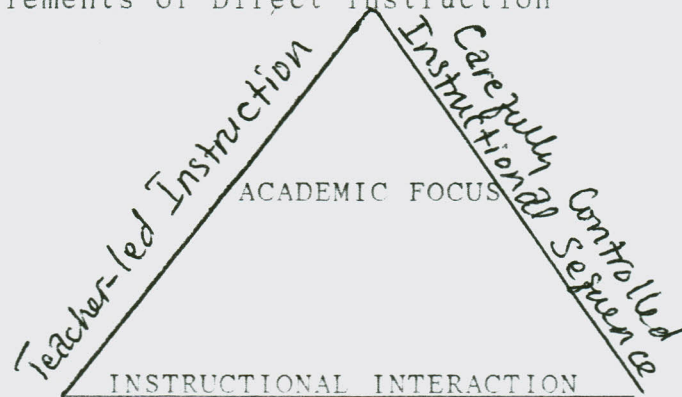
A number of researchers also recognized the instructional functions approach as an active teaching in which each step in

¹ For details of the model and the appropriate methods and techniques for implementing each of the functions, see Appendix I.

the learning process is clearly articulated (Fielding et al.; Good).

And since explicit instruction is unambiguous, clear and detailed, teachers know what they want the students to learn and consequently have a distinct academic focus. The elements that make up the direct instruction or instructional functions are therefore illustrated diagrammatically as follows (Bellon et al.: 237-38):

Fig.1 Elements of Direct Instruction



Clearly Defined Objectives

According to the authors, a strong academic focus is found in the direct instruction format.

... Teachers lead, tell, and show students what they want them to learn. When students have problems, teachers explain, give additional examples, and reteach until they accomplish the learning objectives... but students are not expected to learn new content from ancillary materials (Ibid.).

2.2 Synthesis of Research on the Various Instructional Functions

In the following pages, research findings on each of the six instructional functions are synthesized.

2.2.1 Daily Review and Checking Previous Work

Although all teachers seem to review, the frequency varies. Good and Grouws found that the experimental teachers, who received training, implemented daily review in 91% of the observation time whereas the control group did it in only 62% of the time (1978: 358). According to Rosenshine's report, the use of daily review in maths classes gave teachers the opportunity to assess prerequisite skills and improve student learning. Furthermore, it has been reported that timely reviews that summarize or abstract main points can in most cases help to improve student learning (Bellon et al.: 245).

2.2.2 Presentation of New Content/Skills

It seems obvious that almost all teachers present new information, concepts and skills in almost all of their lessons (Bellon et al.; Perrot, 1982; Rosenshine, 1983). But research studies have shown that teachers spend different time in presenting the new ideas. The following evidences are presented to bolster the above argument:

- (i) the average teachers do 70% of their teaching in primary and secondary classrooms, in which case "Much of this time is spent in presenting new concepts and information to pupils using narration, description and explanation" (Perrot: 19);
- (ii) teachers spend about one quarter of their time lecturing in the typical classroom, and presentation increases at the upper grade levels (Dunkin and Biddle: 369);
- (iii) according to Everston, Emmer and Brophy, the most effective teachers spent about 23 minutes per day in lecture, demonstration, and discussion, compared with 11 minutes for the least effective teachers (Rosenshine, 1983: 339).

So what does one do in effective lectures and presentations? Presentations, or lectures, are usually used to transmit knowledge from teachers to students. However, content knowledge is only one part of what makes some teachers more effective than others. Teachers must also know how to teach their specific content and must have an understanding of students diversity and good presentation skills. "... Effective lectures and presentations, then, are a result of teachers' knowledge, their understanding of instructional processes, and their presentation skills" (Bellon et al.: 241).

Of the presentation skills, recent research on teaching effectiveness points to the importance of teacher clarity.

Furthermore, clarity of instruction is identified as a multidimensional factor (Bellon et al.; McCaleb and White, 1980; Rosenshine, 1983; Rosenshine and Stevens).

Perrot also advocates the idea that "... clarity of presentation is an aspect of behaviour which has considerable influence on the effectiveness of classroom teaching" (33).

Despite the above arguments, investigators of clarity have looked at quite different behaviours as indicators of clarity. The rater most often has been expected to supply his/her own definition of clarity and specific behavioral components of the concept have not been explained (Dunkin, 1986; McCaleb and White).

However, some progress was made during the 1970s in identifying the low-inference correlates of clarity and in exploring their relationships with student achievement. In what follows research evidences have been discussed.

Land and Smith employed a randomized control group, post-test only, experimental design in which (1) the independent variable consisted of two levels of teacher clarity --- a clear lesson versus an unclear lesson --- and (2) the dependent variable consisted of student achievement as measured by criterion referenced test at the comprehension and application categories. The findings suggest that the subjects (freshman and second year students) in the "clear lesson" group achieved significantly more

[$t(48) = 2.28, p < .05$] than students in the "unclear lesson" group (1979: 196-97).

In another study, Land attempted to determine the combined effect of six low-inference variables of teacher clarity --- emphasis on content, clear transition, vagueness terms, mazes, "uh", and additional unexplained content --- on student achievement. He then reported the clarity main effect and the time of achievement (immediate versus delayed) to be significant. However, he found no significant differential effect of level of teacher clarity on student retention (1979: 795-99).

Analysis of studies on teacher clarity by McCaleb and White points to several critical dimensions for the observation and the evaluation of teacher clarity. In the first place, their reviews identified five low-inference components of clarity. These low-inference components of clarity are: "understanding, structuring, sequencing, explaining, and presenting." Secondly, they claim that qualification of raters should include content specialization and teaching experiences. That is to say, observers should have the capacity to judge the accuracy of supporting materials and the appropriateness of terminology. Thirdly, the researchers argue that teacher dynamism should be separated from teacher clarity. A teacher who is supposed to be dynamic is the one who appears more confident, uses fewer non fluency, appears more expressive non verbally, has more eye contact, uses greater vocal variety. Finally, in order to relate teacher clarity to student achievement, a measure of

student opportunity to learn should accompany the measure of teacher clarity. This means that if student achievement is of concern, the evaluator or observer cannot rely on a simple check list of teacher clarity behaviours. Instead, it is claimed, an allowance must be made for the decisions the teacher makes about the inclusion and emphasis of content (27-9). Borg also reported several significant correlations between emphasis or coverage of content by the teacher and pupil achievement, ranging up to 0.67 (1979: 635-45).

At this point, therefore, it seems imperative to identify categories which characterize the factors related to clarity. According to the recent report by Bellon, Bellon and Blank, teacher behaviours related to clarity can be grouped into three main categories:

- substantive (factors related to the content to be learned)
- semantic (factors related to the way teachers use language)
- strategic (deliberate use of strategies to improve learning) [245].

2.2.3 Guided Student Practice

In most successful experimental studies, it has been found that presentation of new content or skills is followed by guided practice. After demonstrating the new content of the subject matter, the teacher asks questions and is also standing by to supply assistance and help, if necessary (Rosenshine, 1983; Rosenshine and Stevens).

From the above view, it is discernible that the guided student practice function is usually dependent upon the teacher's questions and the students' responses. In order to, therefore, synthesize research findings on this function, two topics are considered below: teacher questions, and student response opportunity during guided practice.

Teacher Questions During Guided Practice

Almost all teachers ask questions in their classrooms, and each teacher question yields a (not necessarily correct) student response (Bellon et al.; Brophy and Good; Chewprecha et al., 1980; Perrot).

Whether the questions are factual questions or process questions (which ask for explanation of how an answer is obtained), both correlational and experimental studies have shown that the frequency of questions is positively related to learning (Bellon et al.; Rosenshine, 1983; Rosenshine and Stevens).

For instance, an experimental study by Good and Grouws trained the experimental teachers to assess student comprehension by using (1) process-product questions (active interaction), and (2) controlled practice as part of the experimental treatment. In the final analysis, the experimental teachers held the students accountable for controlled practice in 33% of the time, whereas the control teachers did it in 20% of the time (358). In other words, the trained group had more guided practice and asked

more questions than did the control teachers who continued their normal teaching. Students in the experimental groups had also higher achievement (pre-post gain = 31.01%) than the students of teachers in the control groups (pre-post gain = 19.01%)[Ibid]. Similar results were reported by Anderson and her associates' experimental study (Rosenshine, 1983:341).

Kulik and Kulik also reported that for students in college classes that had weekly quizzes, scores in final examinations were invariably better than they were in classes that had only one or two quizzes during a term. This suggests that additional exercise is also helpful for college students (Rosenshine and Stevens:383).

Based on the above studies, it is true to say that for a better student achievement, it is not only useful to spend considerable time in guided practice, it is also valuable to have a high frequency of questions and problems.

Student Response Opportunity During Guided Practice

In effective instruction student participation is an important variable. According to Levin and Long, and Morine-Dersheimer and Beyerbach, student achievement is positively related to responding to academic questions during guided practice. Furthermore, pupils who participate frequently achieve more than those who do infrequently. This implies that it is not only the frequency of teacher questions which is important but also the

frequency or percentage of correct student responses (Bellon et al.; Rosenshine and Stevens).

It is this influence of participation on achievement that led to studies designed to determine which students have the most opportunity to respond. The following studies are geared towards addressing this question.

According to Brophy and Everston's correlational study and Anderson and her associates' experimental study, student achievement was better if the teacher called on students in ordered turns in primary grades. The reasons are that "...ordered turns insure that all students have opportunities to practice and participate, and [that] they simplify group management by eliminating hand waving and other student attempts to be called on by the teacher" (Rosenhine, 1983:343; Rosenshine and Stevens:384).

However, Anderson and her associates in another study note that the principle of ordered turns would be inappropriate to use in whole-class instruction in most cases. They recommend that in a whole-class instruction, the teacher has to select students to respond to question or has to call on volunteers than to attempt systematic turns (Ibid).

Brophy and Good's Review also supplement the finding that using 'patterned' or ordered turns is more effective in small group settings in primary grades. However, the reviewers have taken the

position that overt verbal participation is not an important achievement correlate in upper grades. They recommend that instead of interacting with the same few students most of the time, it would be profitable if teachers in these grades encourage volunteering and call on non volunteers frequently---especially when they are likely to respond correctly (363).

Ornstein, on the other hand, argues that when teachers use random order, decisions have to be made whether to call on volunteers or non volunteers. The reason behind is that always calling on volunteers can favour the high-achieving, competitive students; and, therefore, volunteers should not be called on more than 15% of the time (Bellon et al.:329).

One final point is worth mentioning. During guided practice, it is recommended by the "Oregon Direct Instruction Model" that teachers ought to use a mixture of both choral responses and individual turns, with choral responding occurring 70% of the time. The individual turns allow for testing of specific pupils (Rosenshine, 1983; Rosenshine and Stevens).

2.2.4 Feedback and Correctives

From the instructional functions model, it is clear that responding to student answers and correcting errors is a major teaching function.

Recently, research on instruction has emphasized on the importance of academic feedback (which means informing students about the correctness of their answers). Researches in the field further claim that such feedback is more strongly and consistently related to achievement. Hawley and Rosenholtz, for example, agree that this relationship is consistent regardless of grade level (Bellon et al.:277). However, Zahoric contends that while the feedback is consistently related to student achievement in basic skills at elementary school level, the evidence in other grade levels is somewhat more complex but still positive on the whole (Gage and Berliner, 1988:558).

Perrot, too, seem to take the position that feedback is a necessary condition for the improvement of practical performance. According to her, if students are given considerable amount of practice without feedback, then their performance does not improve (10).

It seems, therefore, clear that a classroom involves the following typical communication cycle: a teacher question, a student response, and some type of teacher reaction to that answer. This raises the question, how should a teacher, during guided practice, respond to a student's response (Bellon et al.; Brophy and Good; Rosenshine; Rosenshine and Stevens). Once the teacher has asked a question, the student might give a correct response. When a student response is correct: the teacher should simply ask a new question, thereby maintaining the momentum of the practice (Rosenhine, 1983; Rosenshine and Stevens); the teacher should

acknowledge the correct response "... because even if the respondent knows that the answer is correct, some of the onlookers may not"(Brophy and Good: 364); it seems that "... feedback on the correct response has little effect on subsequent performance, except perhaps in the special case where the student has grave doubts about the correctness of the initial answer" (Crooks,1988:456)

On the other hand, the student's response may be incomplete or only partly correct. In such a case, the teacher should affirm or reinforce the correct part by telling the student what was right, and then follow up by giving clues or rephrasing the question or modifying the incorrect part (Brophy and Good; Perrott).

A third case might be when the student gives an incorrect response. According to Rosenshine and Stevens, the teacher has two options for remedying this problem: either provide the students with prompts or hints to lead them to the correct answer (when the student can correct the answer within 30 seconds or less), or reteach the material to the students who do not understand (usually while the rest of the class is doing independent seatwork)[385]. Similarly, after indicating that the response was not correct, research suggests that teachers should try elicit an improved response by rephrasing the question or giving clues (Brophy and Good, Ibid).

Whatever the case may be, Rosenshine stressed that "... errors should not go uncorrected"(1983,1986). It is also argued that errors should be detected and corrected early in the teaching sequence. If this is not done, then errors will become extremely difficult to correct later, and systematic errors or (misrules) can interfere with subsequent learning.

Of course, these suggestions also hold true for effective college teaching as well. According to Kulik and Kulik college instruction was more effective when (a)students received immediate feedback on their examinations, and (b) students had to do further study and take another test when their quiz scores did not reach a criterion. Both conditions imply that students learn better with feedback---as immediate as possible; and errors should be corrected before they become habitual (Rosenhine, 1983, 1986; Rosenshine and Stevens).

In the final analysis, Crooks' review lists three factors which determine the effectiveness of feedback: (1) the correctness of the answer, (2) the student's degree of confidence in the answer, and (3) the nature of the task. The review further stresses that:

... If the answer is correct, simple confirmation of its correctness is sufficient. If the question was factual and the answer is incorrect, the most efficient form of feedback is probably simply to give the correct answer. ... If the question involves comprehension or higher cognitive skills, however, more detailed feedback is desirable. Students who answered such questions incorrectly with high confidence may need help to identify the source of their misunderstanding ..., whereas students who answered the question incorrectly with low confidence may need to be given conceptual help and advised to restudy the material (Ibid).

2.2.5 Independent Practice

During guided practice, students are expected to perform the activities correctly, but hesitantly (Rosenshine, 1986:68). When teachers are quite sure that the guided practice is successful or that the students have prerequisite skills and knowledge, they are expected to move to independent practice.

Independent practice is, therefore, the instructional function through which students are provided opportunities to practice new skills and to increase speed and confidence (Bellon et al., :369). The students need these opportunities to become fluent in a skill and to work on the activities without the cues given during guided practice. Among the many procedures that are taught in a typical school, the following are some of the most important ones which need such fluency and independence: "use a ruler to measure widths, add decimals, read a map, conjugate a regular verb in a foreign language, ..., complete and balance a chemical equation, operate equipment, and apply procedures" (Rosenshine, Ibid.). He further contends that the need for fluency is no exception to facts, concepts and discriminators to be used in subsequent learning.

Seatwork and homework are the two terms of independent practice that students are expected to go through (Bellon et al., :369-70). The merits of these two forms of independent practice have, therefore, been discussed in the ensuing pages.

Seatwork and Student Achievement

Seatwork is the most common form of independent practice. It is an assignment that students are given to carry out without continuous teacher supervision (Bellon et al., Rosenshine, 1983; Rosenshine and Stevens).

Although classes differ on measures of seatwork variables which take the form of content covered, task orientation, academic focus, and engaged time (Gage and Berliner:559), it has been found that teachers must pay attention as to how to maintain student engagement during seatwork (Rosenshine, 1983; Rosenshine and Stevens).

One finding regarding student engagement is that the degree to which students are adequately prepared to do the seatwork exercises affect students' engagement during seatwork (Rosenshine and Stevens: 386). As compared to the less successful teachers who spent less time in presentation and guided practice, students who are adequately prepared during teacher-led practice are more able to succeed during the seatwork. In other words, if seatwork assignment is to be effective, then "... teachers [must] explain the work and go over practice examples with the students before releasing them to work independently" (Brophy and Good: 364). What is more important is that a negative correlation is found between a good deal of explanation during seatwork and student achievement. According to Rosenshine, "... Having a good deal of explanation during seatwork suggests that the initial explanation

was not sufficient or that there were not sufficient practice and corrections before seatwork " (1983: 346-47).

Another finding is that the management of seatwork activity (keeping the students on task during seatwork) affects students' engagement during seatwork (Rosenshine and Stevens: 386). Once the students are released to work independently after teacher-led practice, teachers who are successful managers of seatwork should actively circulate, ask questions, and give explanations to monitor progress and provide help when needed (Bellon et al.; Brophy and Good; Rosenshine, 1983).

Since a longer contact with one student poses a problem of not helping others when they need help, Sparks and Sparks suggested the 'praise-prompt-leave' strategy. "... Teachers are encouraged to emphasize what is correct, be sure the student knows how to proceed, and then go to another student" (Bellon et al.: 371).

Homework and Student Achievement

As explained earlier, homework is form of the independent practice function. As an integral part of the instructional process, Butler stressed that homework should require students to spend time out of class practising, reinforcing, or applying knowledge and skills as well as learning to study independently (Ibid). But does homework improve student achievement? In order to give an answer to this question, the following research evidences are presented.

According to Gage and Berliner's review: (1) the results of the surveys done by the International Association for the Evaluation of Educational Achievement (IEA) indicate that the number of hours of homework per week and student achievement are substantially related; (2) the findings of Keith's large scale statistically controlled correlational study---which employed twenty thousand high school seniors---indicate that homework by itself correlated .32 with grades; (3) the results of Marshall's review of twenty-three experiments in mathematics tell us that homework caused higher achievement, particularly in higher grade levels (7 through 10) and in problem solving as against computational skills. "The implication is that homework can improve achievement and grades" (Gage and Berliner: 458).

On the other hand, Bellon, Bellon, and Blank's review of several extant researches on homework reveals the following findings: (1) whereas larger effects are found in such subject areas as reading and social studies, research on mathematics and science achievement also supports the positive effects of homework. The implication is that homework seems to have grater effects in some subject areas than in others, but on the whole the results are positive; (2) it seems that homework also has greater effects in some grade levels than in others---with high school students benefiting more from homework than junior high students, and elementary students are making minimal achievement gains (372).

In sum, it would be appropriate and necessary to summarize what has been said about independent practice in the following words:

Independent practice is really a continuum in which the students begin their work under teacher supervision and conclude with homework without supervision. When the material is difficult, more time is spent in supervised independent practice [seatwork]; when the material is easier, more of the independent practice can be done as homework (Rosenshine, 1986: 68).

2.2.6 Weekly and Monthly Reviews

Although there seems little experimental research evidence on the benefits of periodic reviews, it has been argued that weekly and monthly reviews also enhance the learning of new material (Rosenshine, 1983; Rosenshine and Stevens). For example, Good and Grouws guidelines for fourth grade Effective Mathematics Instruction included weekly and monthly reviews as one of key instructional behaviours, under the heading "Special Review", and positive relation with student achievement was reported (355-362).

Taking into consideration the fact that frequent tests could be one of the techniques to implement the weekly and monthly reviews function, (see Appendix I) Kulik and Kulik reported the differential positive effects that weekly quizzes have on college students' final examination achievement (Rosenshine, 1986: 68).

2.3 Summary of Finding of the Instructional Functions Approach

The instructional functions approach, or more specifically direct instruction, is a process in which initially the teacher takes full responsibility for performing a task and then he or she

gradually relinquishes the responsibility to the student. This progression, Rosenshine argues, can proceed sequentially from teacher modelling, through guided practice using prompts and hints, to independent fluent performance using seatwork and/or homework by the learner (Ibid).

However, the most important question is that Does the instructional functions approach or direct instruction approach improve student achievement?

According to Good, the answer seems---yes it does! "That direct instruction is associated with increased learning is a common, almost universal conclusion of recent research"(55). Good bolstered this conclusion by reviewing three experimental field studies which presented teachers with the basic instructional principles of the model. The findings of all these three studies suggest that, after training in the use of the model, teachers had an impact on student achievement and that direct instructional principles or instructional functions can be used to enhance student achievement (Ibid:56-62).

In the same year, Ebmeier and Good found that the effectiveness of direct instruction is strongly related to teacher behaviours in implementing the instruction. Within the trained group, let alone the untrained or control group, teachers who implemented most of the functions in the model had greater effects on their students achievement (Janicki and Peterson, 1981:78).

After reviewing such studies, Janicki and Peterson investigated the interaction of student aptitudes with two treatments: the instructional functions approach and a small group variation of this approach. In their final analysis, they came to the conclusion that the teacher is the most important factor for the implementation and effectiveness of direct instruction. They further recommended the elaboration of the mechanism of direct instruction in such a way "...that variations can and should be made within the direct instruction approach to meet the needs of individual students and teachers and, moreover, that training in direct instruction should be varied to meet the needs of individual teachers"(Ibid:80).

Some two years later, Fielding et al., studied the comparative effects of inquiry and instructional functions approaches to instruction at secondary school level in the content area 'legal concepts and principles'. Finally they recommended that

... direct instruction can be adapted successfully to the teaching of complex [as distinct from basic] concepts and skills at secondary school level, at least in this content area. Students in the direct instruction performed significantly better on both multiple choice and essay tests. Moreover, knowledge was retained over a two week period(291).

In an attempt to investigate the relative merits of the instructional functions approach and the "experimental" approach---characterized by flexible use of space, student choice of activity, richness of learning material, integration of curriculum areas, and more individual or small-group than large group instruction---Kierstead concluded that both approaches are

not mutually exclusive but that, in the hands of teachers, they are actually complementary (1985: 25-30).

It seems for the above several reasons that Rosenshine recommended some modifications on the instructional functions approach so that the model will be adjusted to the particular class and type of material being taught. For instance, when the teacher meets faster or older students, or when he/she teaches less difficult material, then review should be as brief as possible and more time can be spent on presenting new concepts or skills. Furthermore, in such cases, less time should be allocated for both guided and independent practice, "...and more of the independent practice can be done as homework because the students do not need as much help and supervision (Rosenhine, 1986: 69). This modification can be summarized in the following table (Ibid: 68).

Table 1. Modifications to Suit Different Students

Slower Students
More review
Less presentation
More guided practice
More independent practice
Faster Students
Less review
More presentation
Less guided practice
Less independent practice

Finally, the following two statements, made by Bellon et al., will suffice to be a summary of this chapter (253-54):

1. Direct instruction [or instructional functions approach] is a systematic strategy designed to teach new information, basic skills, and procedures that can be applied to different situations.

However, such instruction should not be used to the exclusion of other teaching strategies since it may decrease student involvement in the learning process.

2. When direct instruction is used appropriately, students are actively engaged in processing information.

It is recommended that, whenever possible, teachers should present new concepts and skills in small segments using concrete examples that can be applied to the lives of the students, and that the presentation should be alternated with questioning, discussing, and checking for understanding so much so that student achievement will be improved.

CHAPTER THREE

3.DESIGN AND PROCEDURES OF THE STUDY

The experimental design employed was the "Pre test--Post test Control Group Design" represented schematically as follows:

$$R \ O_1 \ X \ O_2$$
$$R \ O_3 \ X \ O_4$$

The above design is also called one of the true experimental designs (Campbell et al., 1963: 183).

In this design the X represents the exposure of the experimental or treatment teachers to the six instructional functions and their respective instructional behaviours with the help of the manual. It also includes the training of these teachers in the use of the manual. the effects of the exposure (X) were measured by using an audio-tape and a checklist.

The Os refer to the testing process. Therefore, O_1 and O_3 refer to the pre-test administered simultaneously to the experimental and control group students, respectively. O_2 and O_4 were the post-tests administered to the respective groups.

The Rs represent the random assignment of the experimental and control groups before the pretest was administered. This specific time for randomization was supposed to be a procedure for achieving pre-treatment equality of the two groups.

In addition to the above two groups, there was another group which received the treatment (X) and the pre- and post-tests (Os), but not observed---hence the name treatment unobserved (TU) group. This group was included in order to control the effect of the presence of the observer on the implementation of the treatment variables and, therefore, on student achievement.

Using the above design, the hypotheses tested in the null form were presented below:

3.1 Null Hypotheses

H₀1: The proportion of implementation of teaching functions by:

- (a) treatment teachers in government schools is equal to that in non government schools
- (b) control teachers in government schools is equal to that in non government schools
- (c) the entire sample of treatment teachers is equal to that of control teachers.

H₀2: The adjusted population means of student achievement are equal for treatment observed, treatment unobserved and control teachers in:

- (a) government schools
- (b) non government schools
- (c) entire sample.

H₀3: There is a zero population correlation coefficient between teachers coverage of chemistry content and student achievement in that content for:

- (a) government schools

- (b) non government schools
- (c) entire sample.

H₀4: There is a zero population partial and part correlation coefficients among fact achievement, comprehension achievement and coverage of chemistry content for:

- (a) treatment observed group
- (b) treatment unobserved group
- (c) control observed group.

These null hypotheses were tested against the alternative hypotheses (presented in chapter 4) at the .05 level of significance.

3.2 Selection of Subjects

In this study the subjects consisted of 24 11th grade chemistry teachers randomly selected from a population of chemistry teachers in Addis Ababa Senior Secondary Schools. In order to get this sample, first 8 schools were randomly selected from a total of 25 senior secondary schools. Then, 3 chemistry teachers from each of the 8 schools were selected randomly. These teachers were finally assigned randomly to treatment observed, treatment unobserved and control groups.

In addition to the teachers, the students of the randomly selected 24 teachers were made part of the sample of this study. Accordingly, a total of 1735 students (571, 559 and 605 in TO, TU and CO, respectively) participated in the study (i.e., in the pre-test and post-test).

3.3 Procedures

In the study 11th grade chemistry classrooms were used just as they have been established as a result of administrative scheduling.

The test items which consisted of knowledge and comprehension levels of the Bloom's Taxonomy were first analyzed for their discrimination index and difficulty level. Both knowledge and comprehension items were constructed using multiple choice questions.

The reasons for classification of the test into fact and comprehension were that upon inspection of the curriculum guide for grades 11-12 (Curriculum Department, 1984:44-46), the writer of these thesis found that 82% of the objectives constitute knowledge and comprehension (55% and 27%, respectively): and that 75% of the activity topics for grade 11 (Curriculum Division, 1983) constitute knowledge and comprehension. Thus, the classification seems reasonable to the researcher (for particular items, see Appendices III and IV).

Before the pretest was administered, the 24 teachers were randomly assigned into treatment observed (TO), and treatment unobserved (TU) and control observed (CO) groups. The first two treatment groups (i.e., TO & TU) were given manuals explaining the models (see Appendix I). They were also trained in the use of the manuals for two days each lasting for two hours. In order

to create A 'Hawthorne control condition'², control teachers were told that they would not get details of the instructional program or the manual until the end of the project. Furthermore, in accordance with Good and Grouws (356-57) study, they were told that it was hoped that this information might be especially useful to them then because at that time they would receive individual information about the program itself. Finally, this teachers were told to continue to instruct their students in their own style. Since the control teachers knew that the project was designed to improve student achievement, one can reasonably feel confident that a strong Hawthorne control was created.

All the students of the three groups were pre tested in March 13, 1992. Except the TU group, both TO and CO were observed periodically for six weeks. (Note that teaching in high schools and hence observations were interrupted during the ESLCE week). Finally, the post test was administered on June 8, 1992 for all the three groups. At the same time each of the 24 teachers were given a copy of the post test and were asked to rate the coverage of the content included in each of the items of the post test on a five point scale using E = teacher emphasized content related to the given item; DC = teacher definitely covered content; PC = teacher probably covered content; DR = teacher did not remember whether the content was covered; NC = teacher did not

²Hawthorne effect is an "increase in motivation deriving apparently from an increase in a groups morale because the group perceives itself as receiving special treatment or consideration" (Good, 1973). "ordinarily, ..., the treatment effects will be more convincing when possible Hawthorne effects are as strong in the control as in the experimental condition" (Linn, 1986:9").

cover content. These data were then quantified by assigning the following numbers: E = 5; DC = 4; PC = 3; DR = 2; NC = 1.

3.4 Validity and/or Reliability of the Instruments

Prior to performing the analysis linking teacher behaviour and student achievement, it was necessary to ensure that ratings of teacher behaviour and student achievement used in the analysis were reliable and/or valid. In other words, the reliability and/or validity of the instruments employed in the study are of crucial importance.

3.4.1 Validity and Reliability of the Achievement Test

The instrument or the pre test was believed to be examined for both content and process validity. Separate but identical validation procedures were used for the validation processes. One group of judges, possessing appropriate backgrounds in chemistry (i.e., at least a diploma in chemistry) content and experiences in high school chemistry program (at least 5 years teaching experience in high school) but not involved in the research project, determined the content validity of the instrument. 5 high school chemistry teachers who met the above criteria were selected and asked to determine the extent of which the given test measures a representative sample of the subject-matter content (chemical equilibrium) and the behavioral change under consideration (Appendix III). All of them agreed that the test is a satisfactory measure of the content and behaviour.

The process validity of the instrument was determined by a second group of judges possessing a working understanding of the Bloom's Taxonomy. 3 educators were given the test and the test specification table and verified (with little differences) that the items are constructed specifically for knowledge and comprehension categories. The advisor of the researcher of this thesis also seemed to agree with the classification.

Still, before the pre test was administered to the sample of the students, item analysis was conducted by administering the test to 115 students who were not participating in the project. The results revealed that

- (a) the discrimination index of the items ranged from 0.4 to 0.6, which implies that, as a pre test---a test consisted of contents which the students are not exposed to---it discriminated highly between the high achievers and the low achievers.
- (b) the item difficulty index ranged from 0.15 to 0.69. This means that the proportion of the total group in which each item was answered correctly ranged from 0.15 to 0.69.

Finally, after the pretest was administered, the reliability of the test was measured using the split-half method.

The formula employed was (Gronlund, 1976:111):

$$\text{Reliability on full test} = \frac{2 \times \text{Reliability on half test}}{1 + \text{Reliability on half test}}$$

The reliability coefficient on the half test was determined by correlating the scores of the even-numbered test items with the scores of the odd-numbered test items. Therefore,

$$\text{Reliability on full test} = \frac{2 \times 0.65}{1 + 0.65} = 0.79$$

The test is, therefore, said to be a reliable test with a reliability coefficient of 0.79. That means, the extent to which the sample of the test items is an adequate sample of the content being measured was 0.79.

3.4.2 Reliability of the Checklist for Coding Implementation of Instructional Behaviours

Recognizing the fact that the observer agreement coefficients are not reliability coefficients (Shavelson et al.: 60), the researcher employed a two way ANOVA method for the determination of the reliability coefficients of the observational instrument or the checklist.

Following the procedures outlined in Lindquist (1953:362-71), 4 teachers were randomly selected or drawn from the 16 chemistry teachers (not including the treatment unobserved teachers for the reason that there were no observational data for them). For each of these subjects, 4 independent measurements of the instructional behaviours outlined in the checklist (Appendix II) were made by each of the 4 coders.

Finally the reliability coefficients among the 4 X 4 X 4 scores of each of the 48 instructional behaviours were determined and entered in the following table.

Table 2. Reliability Coefficients (r) for Items of the Checklist

Item No.	r	Item No.	r	Item No.	r	Item No.	r	Item No.	r	Item No.	r
1.1	.94	2.1	.92	3.1	.82	4.1	.61	5.1	.72	6.1	.90
1.2	.91	2.2	.81	3.2	.85	4.2	.71	5.2	.80	6.2	.89
1.3	.85	2.3	.72	3.3	.75	4.3	.80	5.3	.73	6.3	.72
1.4	.73	2.4	.81	3.4	.80	4.4	.63	5.4	.88	6.4	.64
1.5	.92	2.5	.75	3.5	.81	4.5	.83	5.5	.61		
1.6	.80	2.6	.76			4.6	.72	5.6	.81		
1.7	.84	2.7	.69								
1.8	.81	2.8	.90								
1.9	.79	2.9	.85								
1.10	.49	2.10	.73								
		2.11	.80								
		2.12	.74								
		2.13	.63								
		2.14	.60								
		2.15	.64								
		2.16	.76								
		2.17	.69								

As can be seen in Table 2, the reliability coefficients range from .60 to .94, with the exception of the variable 1.10 in which case $r = .49$. Taken all together, one can say that the measurement of each of the instructional behaviours included in the checklist in each of the 4 observation days by each of the 4 coders (including the researcher) for all the 4 teachers was highly reliable. Therefore, it can reasonably be said that the effects of observers and number of observations in this study were not serious.

CHAPTER FOUR

REPORT AND ANALYSIS OF FINDINGS

This chapter is devoted to presentation, analysis and interpretation of data collected through the various instruments. Its contents are presented under four subheadings each of which is focusing on the test of a specific null hypothesis.

4.1 Test for the Proportion of Implementation of Instructional Functions

The null hypothesis tested was that the proportion (P) of implementation of teaching functions by:

- (a) treatment teachers in government schools (P_1) is equal to that in non government schools (P_2).
- (b) control teachers in government schools (P_1) is equal to that non government schools (P_2).
- (c) the entire sample of treatment teachers (P_1) is equal to that of control teachers (P_2).

That means, $H_0: P_1 = P_2$ or $H_0: P_1 - P_2 = 0$

This hypothesis was tested against the non-directional alternative, $H_a: P_1 \neq P_2$ or $H_a: P_1 - P_2 \neq 0$

The level of significance was established at .05.

The sample statistic for this hypothesis is the difference between the two observed sample proportions, p_1 and p_2 . For convenience, these sample proportions were presented in percent

form in Table 3. The table also presents the calculated test statistic (i.e., Z value) which is to be compared against the critical Z value at the .05 level of significance for two tailed test ($Z_{cv} = \pm 1.96$).

Table 3. Proportion of Instructional Behaviours in Percent and Their Z-Values for the Various Groups

$$Z_{cv(.05)} = \pm 1.96$$

Item No.	Treatment Observed			Control Observed			Entire Sample		
	%G	%NG	Z	%G	%NG	Z	%TO	%CO	Z
1.1	93.3	94.4	-0.15	33.3	38.9	-0.39	93.8	35.4	5.98
1.2	3.3	5.6	-0.38	0.0	0.0	-	4.2	0.0	1.31
1.3	66.7	61.1	0.39	26.7	16.7	0.80	64.6	22.9	4.13
1.4	6.7	11.1	-0.54	6.7	11.1	-0.54	8.3	8.3	0.00
1.5	53.3	66.7	-0.91	16.7	16.7	0.00	58.3	16.7	4.16
1.6	56.7	77.8	-1.48	30.0	27.8	0.16	64.6	29.2	3.54
1.7	23.3	55.6	-2.26	6.7	5.6	0.15	35.4	6.3	3.46
1.8	0.0	0.0	-	0.0	0.0	-	0.0	0.0	-
1.9	3.3	5.6	-0.38	0.0	0.0	-	4.2	0.0	1.31
1.10	10.0	30.0	-2.02	3.3	5.6	-0.38	12.5	4.2	1.51
2.1	66.7	55.6	0.77	26.7	22.2	0.35	62.5	25.0	3.68
2.2	16.7	38.9	-1.72	3.3	5.6	-0.38	25.0	4.2	2.89
2.3	20.0	33.3	-1.03	6.7	16.7	-1.10	25.0	10.4	1.87
2.4	46.7	50.0	-0.22	23.3	22.2	0.09	47.9	22.9	2.55
2.5	83.3	66.7	1.33	26.7	16.7	0.80	77.1	22.9	5.31
2.6	20.0	22.2	-0.18	56.7	61.1	-0.30	20.8	58.3	-3.75
2.7	16.7	16.7	0.00	33.3	44.4	-0.77	16.7	37.5	-2.29
2.8	86.7	77.8	0.86	16.7	33.3	-1.33	83.3	22.9	5.92
2.9	73.3	66.7	0.49	10.0	11.1	-0.12	70.8	10.4	5.98
2.10	20.0	38.9	-1.42	3.3	5.6	-0.38	27.1	4.2	3.10
2.11	66.7	55.6	0.77	23.3	33.3	-0.75	62.5	27.1	3.47
2.12	3.3	0.0	0.77	0.0	0.0	-	2.1	0.0	1.05
2.13	6.7	11.1	-0.54	3.3	5.6	-0.38	8.3	4.2	0.82
2.14	3.3	11.1	-1.08	13.3	27.8	-1.24	6.3	18.8	-1.84
2.15	3.3	5.6	-0.38	10.0	11.1	-0.12	4.2	10.4	-1.17
2.16	53.3	55.6	-0.15	6.7	22.2	-1.57	54.2	12.5	4.26
2.17	23.3	33.3	-0.75	3.3	0.0	0.77	27.1	2.1	3.47

3.1	50.0	55.6	-0.38	23.3	16.7	0.55	52.1	20.8	3.16
3.2	50.0	50.0	0.00	20.0	16.7	0.29	50.0	18.8	3.22
3.3	23.3	16.7	0.55	3.3	5.6	-0.38	20.8	4.2	2.44
3.4	20.0	16.7	0.28	0.0	5.6	-1.30	18.8	2.1	2.65
3.5	33.3	38.9	-0.39	6.7	5.6	0.15	35.4	6.3	3.51
4.1	16.7	11.1	0.53	10.0	11.1	-0.12	14.6	10.4	0.62
4.2	43.3	44.4	-0.07	13.3	11.1	0.22	43.8	12.5	0.31
4.3	20.0	16.7	0.28	0.0	5.6	-1.30	18.8	2.1	2.65
4.4	16.7	16.7	0.00	3.3	11.1	-1.08	16.7	6.3	1.60
4.5	33.3	33.3	0.00	6.7	16.7	-1.10	33.3	10.4	2.69
4.6	23.3	16.7	0.55	3.3	5.6	-0.38	20.8	4.2	2.44
5.1	33.3	33.3	0.00	6.7	5.6	0.15	33.3	6.3	3.29
5.2	30.0	22.2	0.59	3.3	5.6	-0.38	27.1	4.2	3.10
5.3	26.7	27.8	-0.08	0.0	5.6	-1.30	27.1	2.1	3.47
5.4	26.7	27.8	-0.08	0.0	5.6	-1.30	27.1	2.1	3.47
5.5	6.7	5.6	0.15	0.0	0.0	-	6.3	0.0	1.75
5.6	6.7	5.6	0.15	0.0	0.0	-	6.3	0.0	1.75
6.1	60.0	50.0	0.68	13.3	16.7	-0.32	56.3	14.6	4.26
6.2	56.7	38.9	1.20	10.0	16.7	-0.68	50.0	12.5	3.95
6.3	13.3	16.7	-0.32	0.0	5.6	-1.30	14.2	2.1	2.19
6.4	13.3	16.7	-0.32	0.0	5.6	-1.30	14.2	2.1	2.19

Now consider the first four columns of the first row. It lists the item number (1.1) of the instructional behaviour (Did the teacher conduct review?) in the checklist (Appendix II); the proportions in percent (%) of the behaviour observed for treatment teachers in government (%G = 93.3) and in non government (%NG = 94.4) schools; and finally the calculated Z value ($Z = -0.15$).

Since the $|Z| = 0.15$, in the above examples, is less than the critical value of Z ($|Z_{cv}| = 1.96$), the null hypothesis between the treatment groups in government and non government schools was rejected at .05 level of significance.

Similarly, by comparing the calculated Z-value for the control group ($Z = -0.39$) with $Z_{cv} = \pm 1.96$, one can definitely say that

there is no significant difference in implementing the behaviour 1.1 (i.e., conducting review) among the control groups.

So how can it be known: Whether there is a significant difference between the treatment and control groups? Whether the treatment was effective or not?

This can only be known by referring to the last three columns of Table 3. In the table, while the treatment group conducted review in 93.8 (%TO) percent of the observation time, the control groups did it in only 35.4 (%CO) percent of the observation time. This difference in sample proportions ($p_1 - p_2 = 0.938 - 0.354 = 0.584$) resulted in a Z value equal to 5.98, which is greater than $Z_{cv} = 1.96$. Therefore, for this particular instructional behaviour (1.1), the null hypothesis of no difference was rejected in favour of the nondirectional alternative at the .05 level of significance.

Based on analysis and interpretation of data discussed above, generalizations can be made about the 48 instructional behaviours listed in Table 3 under six categories:

(a) Of the 48 behaviours, the treatment teachers in government schools differed significantly from those in non government schools in only two behaviours (1.7 & 1.10, see Appendix II for these particular behaviours). Although there is no empirical evidence which suggests that teachers with fewer number of students make the students correct each other homework paper, it seems to the researcher that the significant difference ($Z = -$

2.26 for 1.7) is attributable to the smaller number of students in government schools. However the significant difference for 1.10 ($|Z| = 2.02 > 1.96$) seems to the researcher a matter of lack of skill in coding this particular behaviour. The evidence can be found from the reliability of coding this behaviour, which is equal to 0.49 (see Chapter 3).

(b) Similarly, in fact with no exception, the null hypothesis of no difference between control teachers in government and those in non government was accepted.

(c) However, the entire treatment teachers did not differ significantly from the control teachers in the following 14 instructional behaviours (see Appendix II): 1.2, 1.4, 1.9, 1.10; 2.3, 2.12, 2.13, 2.14, 2.15; 4.1, 4.2, 4.4; 5.5, 5.6. That means, these behaviours did not indicate $|Z|$ values greater than 1.96.

Some reasons can be advanced for the acceptance of the null hypothesis for the above 14 variables: (1) the short period of training time (two days each lasting two hours) may not be sufficient for experimental teachers to master the skills necessary for implementing these behaviours; (2) the relatively few number of observations per teacher may not be sufficient to get enough data on these behaviours. This is so because some of the variables may be experienced or mastered towards the end of the observation days; (3) due to the overlap of indicators of some behaviours with others, coders of the audio record might have over-coded some variables and under coded the others.

But the most important point is that does the difference in implementation of the 34 instructional behaviours have any effect on student achievement? This is the focus of the second null hypothesis.

4.2 Test for the Adjusted Population Means of Student Achievement

The null hypothesis tested was that the adjusted population means (μ') of student achievement are equal for treatment observed (μ'_1), treatment unobserved (μ'_2) and control observed (μ'_3) teachers in:

- (a) government schools
- (b) non government schools
- (c) entire sample.

That means, $H_0: \mu'_1 = \mu'_2 = \mu'_3$

and the alternative hypothesis is, $H_a: \mu'_1 \neq \mu'_2 \neq \mu'_3$

To test the above null hypothesis, analysis of covariance (ANCOVA), with the pretest (X) serving as a covariate and the post test (Y) as the criterion variable, was employed and the level of significance was established at .05. The data for ANCOVA is presented in Table 4. As can be seen from the table, the means of the X scores in TO, TU and CO group are almost identical in each of the three school types (4a, 4b and 4c). This means that at the beginning of the project, the groups are said to be comparable. This can be substantiated by looking at the comparable X standard deviations (s_i) of the groups in each of the three schools types (government, non government, and entire schools).

Table 4. Data for ANCOVA(a) For the Government Schools

	TO	TU	CO	Total
	X Y	X Y	X Y	X Y
n	449	432	480	1361
X,Y	8.63,17.47	8.60,17.16	8.65,13.49	8.63,15.97
s_x, s_y	3.19,4.78	3.24,4.45	3.30, 4.85	3.30, 5.12
(b) <u>For the Non government Schools</u>				
n	122	127	125	374
X,Y	8.75,19.75	8.99,19.68	8.72,13.15	8.82,17.52
s_x, s_y	2.27,3.10	2.53,3.11	2.36,4.14	2.39,4.67
(c) <u>For the Entire Sample</u>				
n	571	559	605	1735
X,Y	8.66,17.96	8.68,17.73	8.67,13.42	8.67,16.30
s_x, s_y	3.01,4.57	3.10,4.31	3.13,4.71	3.08,5.00

Above all, the nature of the design of the experimental research itself ensures pre-treatment equality among the groups (see Chapter 3).

In terms of raw scores each group showed a substantial increase in achievement. For example, in Table 4a the TO group began the project with a mean (X) of 8.63 and completed the project with

a mean ($\bar{Y}$) of 17.47, the net gain score being 8.84. Similarly, the CO group has a net gain score of 4.84.

However, the most important point is that: are these two gain scores (in fact others, too) significantly different to reject the null hypothesis of no difference? The answer to this question lies in determining the test statistic for ANCOVA and comparing it with its critical value. The test statistic for ANCOVA is the F ratio, and the following are summary tables for ANCOVA.

Table 5. Summary ANCOVA

(a) For the Government Schools

Source	SS	df	MS	F	F_{cv}
Covariate	25864.07	1	25864.07	8536.00	3.84
Between	4601.50	2	2300.75	759.32	3.00
Within	4112.07	1357	3.03		
Total	34577.64	1360			

(b) For the Non government Schools

Source	SS	df	MS	F	F_{cv}
Covariate	2658.77	1	2658.77	489.64	3.84
Between	3415.16	2	1707.58	314.47	3.00
Within	2007.44	370	5.43		
Total	8081.37	373			

(c) For the Entire Sample

Source	SS	df	MS	F	F _{cv}
Covariate	28620.33	1	28620.33	6980.57	3.84
Between	7649.90	2	3824.95	932.91	3.00
Within	7093.91	1731	4.10		
Total	43364.14	1734			

It is easily discernible from the above three tables that all of the calculated F ratios are greater than the critical F values. Since the observed value of the F ratio for the covariate ($F_a = 8536$, $F_b = 489.64$, & $F_c = 6980.57$) exceed the critical value ($F_{cv} = 3.84$), the null hypothesis of no relationship between the covariate and the dependent variable is rejected at the .05 level of significance.

Similarly, since the observed F values for the adjusted population means ($F_a = 759.32$, $F_b = 314.47$, & $F_c = 932.91$) exceed the critical value ($F_{cv} = 3.00$), the null hypothesis is rejected. The conclusion at this point is that at least one pair or combination of adjusted means differs. But which pairs? The TO - TU, or the TO - CO, or the TU - CO?

In accordance with Hinkle et al. (1988: 449), the Tucky/Kramer (TK) method of multiple comparison test was employed to determine which pair or combination of means differs. Table 6 presents summary of the test statistic (Q) using the TK method.

Table 6. Summary of Q Using the TK Procedure

Type of School	Q_{TO-TU}	Q_{TO-CO}	Q_{TU-CO}	$Q_{cv(.05)}$
Government	3.25 [†]	49.51	45.61	3.31
Non government	1.59 [†]	31.57	30.14	3.31
Entire Sample	2.91 [†]	53.53	50.59	3.31

* Those Q values which are less than the Q_{cv} .

The data in Table 6 is interpreted in such a way that if the calculated Q value is greater than the Q_{cv} , then one can be sure that there is a difference between the adjusted population means of the groups which are compared.

Accordingly, the data in Table 6 led to the following conclusions:

1. The adjusted population mean of the treatment observed group (μ'_1) is different from that of the control observed group (μ'_3) in all school types.
2. The adjusted population mean of the treatment unobserved group (μ'_2) is different from that of the control observed group (μ'_3) in all school types.
3. There is no difference in the adjusted population means of the treatment observed (μ'_1) and treatment unobserved (μ'_2) groups in all school types.

The conclusions might be substantiated by answering the following question: Is there any common measurable variable for all the three group of teachers (since implementation data is not present for TU group) that can bring any significant difference in

student achievement? One variable that the researcher found to be common to all the three group of teachers is the extent of coverage of chemistry content included in the items of the post test. This is discussed in the ensuing pages.

4.3 Test for a Population Correlation Coefficient Between Content Coverage and Student Achievement

The null hypothesis tested was that there is a zero population correlation coefficient (ρ) between teachers coverage of chemistry content and student achievement in that content:

- (a) for the government schools
- (b) for the non government schools
- (c) for the entire sample.

That means, $H_0: \rho = 0$ and $H_a: \rho > 0$

In this case teacher coverage scores for each teacher were correlated with student achievement scores of that particular teacher using the linear regression analysis model. Table 7 presents the results of the analysis.

Table 7. Means (Standard Deviations), Correlation Coefficients
and t-values for Content Coverage and Achievement

Group	Mean (Standard Deviation)		Statistic		
	Coverage	Achievement	r	t	
TGO	89.00 (7.87)	17.47 (1.78)	.880	3.213	3
TGU	89.40 (7.13)	17.16 (2.47)	.978	8.076	
CGO	64.40 (9.97)	13.49 (1.72)	.488	0.968	
TNO	88.33 (4.16)	19.75 (2.08)	.999	22.338	4
TNU	85.33 (5.13)	19.68 (2.56)	.986	6.001	
CNO	60.10 (3.92)	13.15 (1.03)	.532	0.628	
ETO	88.75 (6.36)	18.30 (2.20)	.686	2.310	5
ETU	87.88 (6.49)	18.11 (2.66)	.642	2.051	
ECO	62.79 (8.13)	13.36 (1.42)	.500	1.414	

As can be seen from Table 7 except for the control groups in all the three school types (i.e. CGO, CNO, and ECO), all the treatment groups (observed and unobserved) have significant correlation coefficients (and t-values) between the teachers' coverage scores and their students achievement scores.

However, the achievement tests were constructed in such away that they are composed of fact questions and comprehension questions. So which one of these two question categories contributed more

³ r_{cv} and t_{cy} for TGO, TGU, and CGO are .805 and 2.353, respectively.

⁴ r_{cv} and t_{cy} for TNO, TNU, and CNO are .988 and 6.314, respectively.

⁵ r_{cv} and t_{cy} for ETO, ETU, and ECO are .622 and 1.943, respectively.

to the relationship existing between teachers' content coverage and pupils' achievement? The answer to this question is the focus of the next topic.

4.4 Test for Population Partial and Part Correlation Coefficients Among Fact Test, Comprehension Test and Content Coverage.

The null hypothesis tested was that there is a zero population partial and part correlation coefficient (p) among the fact achievement test (X), comprehension achievement test (Y) and teachers' coverage of content (Z):

- (a) for the treatment observed group
- (b) for treatment unobserved group
- (c) for the control group.

That means, $H_0: p = 0$ and $H_a: p > 0$.

Based on the test specification table (Appendix III), students' achievement data were splitted into fact (X) and comprehension (Y) scores. These scores were then correlated with teachers content coverage (Z) between themselves. Finally, partial and part correlations were calculated. These data are presented in Table 8.

Table 8. Means (Standard Deviations) and Correlation Coefficients for Content Coverage, Fact and Comprehension Test Achievement.

Group	Mean Standard Deviation			Correlation Coefficients ⁶						
	X	Y	Z	r_{xy}	r_{xz}	r_{yz}	$r_{yz.x}$	$r_{z(y.x)}$	$r_{xz.y}$	$r_{z(x.y)}$
ETO	10.70	7.60	88.75	-.17	.23	.60	.67	.65	.42	.33
	1.07	1.99	6.36							
ETU	8.63	9.48	87.88	-.19	.18	.59	.65	.64	.38	.30
	1.81	2.33	6.49							
ECO	7.12	6.24	62.79	-.33	.41	.16	.35	.32	.50	.49
	1.27	1.19	8.12							

As can be seen from Table 8, the calculated partial and part correlations between Y and Z ($r_{yz.x}$ and $r_{z(y.x)}$, respectively) are greater than the critical value (.62) for both treatment observed and unobserved groups. This means that when the effect of the fact achievement test (X) is removed from both the comprehension achievement test (Y) and content coverage (Z), the correlation between Y and Z raises (a) from .60 (r_{yz}) to .67 for the ETO; and (b) from .59 to .65 for the ETU. Had it not been for the removal of the effect of X from both Y and Z, the original zero order correlation coefficients (.60 and .59) would have been insignificant as compared to the critical value (.62).

Furthermore, when the effect of X is removed only from Y (i.e., part correlation), the correlation between Y and Z still raises

⁶ $r_{cv} = .62$

for both treatment groups [$r_{z(y,x)} = .65$ and $.64$ for ETO and ETU, respectively]. But these increases are not as high as in the partial correlation cases.

The above phenomena may be explained in the following ways. First of all, little negative zero order correlations were observed between X and Y. Secondly, little positive zero order correlations were observed between X and Z. Therefore, the removal of these little correlations from both will increase the partial correlation as compared to the removal of the little correlation from only the variable that is negatively related.

In the case of the control group, no significant partial and part correlations were observed. However, one important fact is worth mentioning. While both treatment groups have greater zero order correlation coefficients between Y and Z than between X and Z, the reverse is true of the control group. It might be possible, if not necessarily true, to say that teachers who did not receive training in the use of the direct instruction approach are less able to contribute to the comprehension level of student achievement as compared to those teachers who received the training. But this requires further research to prove its validity.

CHAPTER FIVE

5. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This chapter summarizes the major findings of the study and then concludes on the basis of these findings. Finally, feasible recommendations are provided.

5.1 Summary

Summary of the findings are made based on the null hypotheses discussed in chapter 4.

1. The null hypothesis of no difference

$$H_0: P_1 = P_2 \quad \text{or} \quad P_1 - P_2 = 0$$

for treatment teachers in government and non government schools was accepted at the .05 level of significance. That means, the treatment teachers were alike irrespective of the school type. This was also true for control teachers of the two school types.

However, the null hypothesis of no difference for the 34 variables (out of 48) between the entire treatment and entire control teachers was rejected in favour of the nondirectional alternative hypothesis,

$$H_1: P_1 \neq P_2 \quad \text{or} \quad P_1 - P_2 \neq 0.$$

In other words, there were significant differences in implementation of teaching functions between treatment and control teachers. The treatment teachers were also found

implementing the behaviours more than the control teachers did.

2. It was also found that students of the treatment teachers (both observed and unobserved) were better in achievement than students of the control teachers. Furthermore, the presence of the observer was found to have no significant effect on implementation of instructional behaviours and student achievement.

3. The null hypothesis of no difference

$$H_0: p = 0$$

between teacher's content coverage and students' achievement in that content was rejected for the entire group in favour of the directional alternative,

$$H_a: p > 0.$$

That is to say, there were significant correlations between teachers' content coverage and students' achievement in that content for those teachers who received training in the use of the instructional functions approach.

4. The null hypothesis of no difference

$$H_0: p = 0$$

among the fact achievement, comprehension achievement and teachers' content coverage was rejected in favour of the directional alternative,

$$H_a: p > 0$$

for treatment observed and unobserved groups. In other words, significant correlations were found among the above three variables for treatment teachers (both observed and unobserved).

5.2 Conclusions

Given the relatively short period of treatment program and the relative ease of implementation, the results of this study are important.

One can, in most cases of this study, say that the experimental treatment worked very well and brought significant differences between treatment and control teachers, irrespective of the school type under investigation.

Although the results suggest that the treatment was generally effective, the most reasonable interpretation, at this point, is that the instructional treatment, when implemented, has a positive impact on student achievement. The importance of particular variables, as in the study of Good and Grouws (361-2), can only be evaluated in subsequent studies that delete certain aspects of the instructional program.

For example, the 14 variables that showed insignificant differences would seem to need clarification in future research. Associated with these instructional variables is the need to improve the observation scale for them.

In general, continued efforts to improve and refine the entire treatment are necessary if more insight into the teaching of chemistry in Ethiopian Senior Secondary Schools is to be achieved.

5.3 Recommendations

As explained earlier, the results of this study are important. Particularly, the large magnitude of the treatment effect is important and offers convincing proofs that it is possible to intervene successfully in Ethiopian high school chemistry programs.

More important for student achievement, as far as this study is concerned, are that:

- (a) an exhaustive training of experimental teachers
- (b) a good mastery of the skills involved in each instructional functions on the part of teachers.

However, considerable follow up activity is necessary. For example, the impact of the program on different types of students and teachers needs to be investigated more fully.

It seems also important to get detailed information about the relationship between individual aspects of the program and student achievement gains.

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APPENDIX I
MANUAL OF METHODS AND TECHNIQUES NEEDED TO IMPLEMENT THE SIX
INSTRUCTIONAL FUNCTIONS BY ELEVENTH GRADE EXPERIMENTAL
CHEMISTRY TEACHERS

Table of Contents

Preface

1. Guidelines for Eleventh Grade Chemistry Instruction
2. Methods and Techniques for Implementing Each of the Six Instructional Functions
3. Suggestions on Questioning Techniques
4. Suggestions on the Use of Algorithms for Solving Generic and Harder Problems in Chemistry

Glossary

Preface

This manual of methods and techniques is prepared for eleventh grade chemistry teachers who are participating as treatment teachers or experimental groups in the research program entitled: The impact of Chemistry Teaching by "Instructional Functions Approach" on Student Achievement: An experimental Study of Grade Eleven.

In the first part of the manual, the six "Instructional Functions" with their instructional activities are listed. The teacher is allowed or advised to select among the very activities those which he/she considers important and feasible to his/her students, to the specific content and to the time allotted for the specific function.

The second part is aimed at providing methods and techniques for implementing those activities outlined in the form of a pattern in the first part. this part is deemed important in view of the fact that the teacher will get a clear picture of what the instructional functions are and also how they are going to be implemented. But by no means the teacher is required to use all these methods and techniques in a single lesson or period.

In the third part of the manual, a specific technique of teaching--questioning technique--is discussed. this technique is important for teachers in almost all of their lessons.

The last part deals with the use of algorithms in solving mathematical problems in chemistry. Whenever the teacher is dealing with mathematical problems, s(he) is advised to use a specific algorithm relevant to the problem. this part is also by no means considered to be exhaustive rather it is considered as a guideline or an example for the use of algorithms.

Finally, a glossary of important terms and phrases is provide .

February 1992

1. GUIDELINES FOR ELEVENTH GRADE CHEMISTRY INSTRUCTION

The following guidelines involved a set of instructional principles organized into a model or pattern (shown in Table I) calling for briskly paced whole-class instruction supplemented by homework assignments.

Table 1. Summary of Key Instructional Behaviours (Functions)

1. Daily review and checking homework (first 5 minutes except the first meeting of every week).
 - a. Review the concepts and skills associated with the homework.
 - b. Collect and deal with homework assignments.
 - c. Ask several questions.
 - d. Reteach when necessary.
2. Presentation or Development (about 20 minutes).
 - a. Provide short statement of objectives.
 - b. Provide overview and structuring.
 - c. Proceed in small steps but at a rapid pace.
 - d. Focus on meaning and promoting student understanding by using lively explanations, demonstrations, process explanations, illustrations, and so forth.
3. Guided practice (about 6 minutes).
 - a. Initially guide students using controlled practice.
 - b. Use high frequency of questions.
 - c. Also use covert rehearsal, restating and reviewing.
 - d. Check for understanding (CFU) by evaluating student responses.
 - e. Continue guided practice until students are firm.
4. Correctives and feedback.
 - a. Ask another question or provide a short acknowledgment of correctness (i.e., "That is right") after quick, firm and correct responses.
 - b. Provide process feedback (i.e., "Yes, Netsanet, that is right because ...") after hesitant correct answers.
 - c. Try to elicit an improved response when the first one is incorrect.
 - d. Try to obtain a substantive response to each question.
 - e. Use praise in moderation; specific praise more effective than general praise.
5. Independent practice or seatwork (about 9 minutes)
 - a. Provide uninterrupted successful practice.
 - b. Maintain momentum; get everyone involved, then sustain involvement.
 - c. Alert students to the fact that their

- work will be checked at the end of the period.
- d. Promote accountability--check the students work.
 - e. Practice until responses are firm, quick, and automatic.
6. a. Weekly review.
- 1. Conduct during the first 20 minutes of each of your first-day meeting within the week.
 - 2. Focus on skills and concepts covered during the previous week.
 - 3. Include review in homework.
- b. Monthly review.
- 1. Conduct every fourth first-day meeting of the weekly periods.
 - 2. Focus on skills and concepts covered since last monthly review.
 - 3. Use frequent tests.
 - 4. Reteach material missed in tests.
- N.B.: Homework assignments
- a. Should be assigned on a regular basis at the end of each chemistry class except the last meeting of your weekly periods (for example, except friday).
 - b. Should involve about 15 minutes of work to be done at home.
 - c. Should include one or two review problems.

Of these six functions, (1) demonstration or presentation, (2) guided practice, and (3) independent practice form the instructional core. The first step is the demonstration of what is to be learned. This is followed by guided student practice in which the teacher leads the students in practice, provides prompts, checks for understanding, and provides corrections and repetitions. When the students are firm in their initial learning, the teacher moves them to independent practice where the students work with less guidance.

For example, how would one teach balancing of chemical reactions using these steps? The first step would be teacher demonstration

(or presentation) of the steps followed in solving problems which involve balancing of chemical reactions. For instance, the teacher would model the use the steps by using some problems on the chalk board. This is followed by guided practice in the students work one or two problems and the students are guide through the rules with teacher prompts. The teacher circulates and checks for understanding as they do the problems. As the students become more proficient, the prompts are diminished. The frequency of student errors during guided practice gives the teacher an indication of whether any student needs reteaching on the material. When a student or subset of students make frequent errors, the teacher would review or reteach the skill or process for the students or the entire class. When the students are firm in the guided practice, and are making few errors, they are moved to independent practice where they practice learning how to do the skill (of balancing chemical reactions) accurately and rapidly.

2. METHODS AND TECHNIQUES FOR IMPLEMENTING EACH OF THE SIX INSTRUCTIONAL FUNCTIONS

2.1. Daily Review and Checking Homework

In order to carry out this function, the teacher can use any one or more of the following suggestions:

- Ask questions about concepts or skills taught in the previous lesson.
- Give a short quiz at the beginning of class on material from previous lessons or homework assignments.

- Have students meet in small groups (2 to 4 students per group) to review homework.
- Have students prepare questions about previous lessons or homework and ask them of each other, or have them the teacher ask of the class.
- Have students prepare a written summary of the previous lesson.
- Have the students ask the teacher about problems on homework and the teacher reviews, reteaches or provides additional practice.

2.2. Presentation of Material to be Learned

All teachers, of course. Demonstrate (or present) new skills and materials. But the clarity of presentation differs from one teacher to another. For that reason to be an effective teacher, one should try to understand and hence implement the following aspects of clear presentation.

Table 2. Aspects of Clear Presentation

- | |
|---|
| <ol style="list-style-type: none">1. Clarity of goals and main points.<ol style="list-style-type: none">a. State the goals or objectives of the presentation.b. Focus on one thought (point, direction at a time).c. Avoid digressions.d. Ambiguous phrases and pronouns.2. Step-by-step presentation.<ol style="list-style-type: none">a. Present the material in small steps. |
|---|

- b. Organize and present the material so that one point is mastered before the next point is given.
 - c. Give explicit step-by-step presentation (when possible).
 - d. Use algorithms (when necessary).
 - e. Present an outline when the material is complex.
3. Specific and concrete procedures.
- a. Provide a pattern for the skill or process (when appropriate).
 - b. Give detailed and repeated explanations for difficult topics.
 - c. Provide students with concrete and varied examples.
4. Checking for students understanding.
- a. Be sure that students understand one point before proceeding to the next point.
 - b. Ask the students questions to monitor their comprehension of what has been presented.
 - c. Have students summarize the main points in their own words.
 - d. Reteach the parts of the presentation that the students have difficulty comprehending either by further teacher explanation or by students tutoring other students.

2.2. Guided Student Practice

It is well known that almost all teachers spend time in guided practice. But it is recognized that effective teachers spend more time asking questions, correcting errors, repeating the new material, and working problems with teacher guidance than do less effective teachers.

In addition, the form of guided practice is modified to fit the material being taught. When a process is being taught, as in balancing a chemical reaction or solving mathematical questions involving molar volume, equilibrium, etc., the guided practice frequently consists of problems worked under the teacher's supervision, and the teacher restating the steps as the students proceed (i.e., providing what is called process feedback). Teachers frequently have some students doing the mathematical problems on the board, thus providing models of procedures for the entire class.

On the other hand, when facts are being taught--as in historical facts about the works of chemists, scientific facts and other specific chemical facts--then there is less process feedback and more questions and answers during guided practice.

In general, the following suggestions are helpful to teachers during guided practice.

1. Ask a large number of questions (particularly higher order).
2. Guide students in practising the new material, initially using prompts to lead students to the correct response and later reducing them when students are responding correctly.
3. Check for student understanding (CFU). Some techniques for conducting CFU include:
 - Prepare a large number of oral questions before hand.
 - Ask many brief questions on main points, supplementary points, and on the process being taught.

- Call on students whose hands are not raised in addition those who volunteer.
 - Ask students to summarize the rule or process in their own words.
 - Have all students write the answers (on paper or chalk board) while the teacher circulates.
 - Have all students write the answer and check them with neighbour.
 - At the end of a lecture/discussion, write the main points on the board and have the class meet in groups and summarize the main points to each other.
4. Provide feedback.
 5. Correct errors.
 6. Petch when necessary.
 7. Provide a large number of successful repetitions.

2.4. Correctives and Feedback

This teaching function involves responding to student answers and correcting student errors. Practically, student responses could be categorized into four types.

1. Correct, Quick and Firm

When a student response is correct, quick and firm, the teacher should simply ask a new question, thereby maintaining the momentum practice. The teacher is also advised to give short statements of acknowledgement (e.g., "right") which do not disturb the momentum of the lesson.

2. Correct, but Hesitant

If students are correct but unsure of themselves, it is suggested that teachers provide short statement of feedback such as "Correct" or "Go ahead". It is also suggested that the teacher provide moderate amounts of process feedback, that is, re-explain the steps used to arrive the correct answer.

3. Incorrect, but a "Careless" Error

When a student makes a careless error, teachers should simply correct the student and move on.

4. Incorrect, Suggesting Lack of Knowledge of Facts or a Process

In such a case, the teacher has two options for remedying this problem:

- a. Provide the students with prompts, hints or simple questions to lead them to the correct answer. However, this is useful only when these individual contacts remain brief (e.g., 30 seconds or less).
- b. Reteach the material to the students who do not understand. Usually this reteaching occurs while the rest of the class is doing independent seatwork.

2.5. Independent Practice (Seatwork)

Once students are exhibiting some proficiency on the new concepts or skills, they are ready to begin practising on their own. The following are suggestions for improving students engagement during seatwork:

1. Give clear instruction---explanations, questions and feedback---and sufficient practice before the students begin their seatwork.
2. Circulate during seatwork, actively explaining, observing, asking questions, and giving feedback.
3. Have short contacts with individual students (i.e., 30 seconds or less).
4. For difficult material in whole-class instruction, have a number of segments of instruction and seatwork during a single period.
5. Arrange seats to facilitate monitoring the students (e.g., face both small group and independently working students).
6. Establish a routine to use during seatwork activity which prescribes what students will do, how they will get help and what they will do when they have completed the exercises. For example, the routine might specify that:
 - a. Students who have completed the exercises are to turn them in and work on other assignments or do free reading or enrichment exercises.
 - b. Students are to check their exercises with prearranged "buddies".
 - c. Students who need help are to approach the teacher between, not during, small group activities.
 - d. Students who need help may quietly ask preassigned peer tutors.

2.6. Weekly and Monthly Reviews

The learning of new material is also enhanced by weekly and monthly reviews. As such, you are advised to review the previous

week's work in your first-day meeting of every week's periods for chemistry, and to conduct a monthly review in your first-day meeting of every four week's periods for the subject.

For example, your first-day meeting might be Monday third period. Therefore, you are required to review the previous week's work or lessons every Monday third period. You are also required to conduct a monthly review every fourth Monday third period.

3. SUGGESTIONS ON QUESTIONING TECHNIQUES

It has been demonstrated that questioning is an essential ingredient of inquiry and discovery and consequently should be fostered in science education. It is also claimed that a good question should be carefully worked or framed. In other words, it should be simply worded, well defined, reasonable, relevant to the matter being discussed, and demanding or thought-provoking.

The questions might be classified into two classes: Over headed questions and Directed questions. In over headed questions, the group or the class will be asked as a whole and hence anyone can answer them. On the other hand, directed questions are focused on individual students. Only the person named can answer them. Generally speaking, during lectures, lessons, and quizzes, directed questions are better than over headed questions. The following suggestions are therefore recommended while asking directed questions:

1. Address the question to the group as a whole.
2. Allow a reasonable period of time to elapse. In other

words, pause for 3 to 5 seconds after asking a question, but before calling on a pupil. For example, immediately after asking the question, the following verbal prompt can be presented:

"Please think over your answer carefully",

"When I call on you, I want you to give me a complete answer", then pause for 3 to 5 seconds before you call on someone.

3. Call on a specific student by name. It is necessary to avoid always asking the same students. You should also ask students who do not raise their hands.
4. Establish and maintain eye contact with the student while the response is made.
5. Deal with the students response. There are various cases of the student's response. The pupil might give:
 - a. An I don't know response. In this case the question might be either ambiguous or too vague. Therefore, you need to rephrase your question. For example: The question, "What do you think about water?" is more ambiguous than the same question phrased "Why has water been called a universal solvent?" Similarly, you are likely to receive a better response from "What are the factors that influence the rate of chemical reactions?" than from "How do chemical reactions proceed?"
 - b. A very weak response. If you think that your question is clear enough, begin prompting by using a series of questions containing hints that help the student develop his or her answer. For example: A pupil may not be able

to answer a question about the effects of electronegativity difference upon the chemical and physical properties of a compound. But he or she may begin to respond to a series of questions beginning with "What happens to the electron cloud which bonds two atoms together when the two atoms have different electronegativities?", followed by "Why could very small dipole moments result when the electronegativity difference between the two atoms is small?"

The questions could also contain direct hints, for example, "To which side do you find a greater proportions of negative charge in a bond formed between chlorine (Cl) and carbon (C)?"

- c. A partly correct response. In this case, first reinforce the correct part by telling the pupil what was right, and then by modifying the incorrect part.
- d. A correct response. When you have got a correct response, repeat it and also indicate that it was correct. You might say something like: "Yes, that is right...."

Questions could also be classified into six types based on the Bloom's Taxonomy of Educational Objectives. Questions at each level require a response which uses a different kind of thought process. The levels are also arranged hierarchically in ascending order of complexity.

1. Knowledge: When your purpose is to determine whether pupils remember specific facts, ask recall questions.

- Examples: a. When did Dalton formulate his atomic theory?
b. Who discovered the electron?

The following words are often found in knowledge questions: Who? What? Where? When? Define Recall Recognize Name.

2. Comprehension: When your purpose is to help pupils organize facts in such a way as to make some sense of them, ask comprehension questions.

- Examples: a. Compare the properties of ionic compounds with those of covalent compounds.
b. How did Dalton's atomic theory differ from modern atomic theory?

The following words are commonly found in comprehension question: Describe Compare Contrast Put in your own words Explain.

3. Application: When your purpose is to encourage pupils to apply information they have learned in order to reach an answer to a problem, ask application questions.

- Examples: a. When a pupil is asked to apply what he/she has learned about systems at equilibrium by answering the question:
What will happen if the pressure on the following system is increased?



- b. When a pupil is asked, 'Give three examples of ionic compounds.' in order to apply what he has learned about ionic compounds.

Words commonly found or implicit in application questions are: Apply Classify Use Choose Employ Give an example.

4. Analysis: When your purpose is to help pupils not only to remember and organize information, but also to analyze it for underlying reasons such as cause and effect, explanatory-type questions are asked.

Examples: a. What factors influence the first element in a group to be different from the rest of the elements in that group?

b. Why was an atom once supposed to be the smallest particle of an element?

c. What causes the inclusion of the mass of the nucleus to the Rydberg equation?

The following words are commonly used in analysis questions: Why? What factors? Draw conclusions Determine evidence (support, analyze).

5. Synthesis: When your purpose is to help pupils to form relationships and put things together in new or original way, ask synthesis questions.

Examples: a. How can we find out if this is CO₂?

b. What problems are likely to occur with Niels Bohr suggestion that the atomic nucleus was surrounded by electrons moving in orbits like planets round the sun?

The following words are common in synthesis questions: Predict Write Develop What would happen if ...?

6. Evaluation: When your purpose is to help pupils choose among alternatives by judging which best fits some stated values, ask evaluation questions.

Examples: a. "An atom is the smallest particle of an

element." Should this statement be defended or rejected? For what reasons?

b. Which statement most accurately describes the Heisenberg's uncertainty principle?

Words often used in evaluation questions include: Judge Assess Decide Justify.

Note that those questions which require the pupil to recall information---as in knowledge questions---are called Lower-order questions. And those which require the pupil to compare, contrast, explain, summarize, analyze, synthesize or evaluate are called Higher-order questions.

4. SUGGESTIONS ON THE USE OF ALGORITHMS FOR SOLVING GENERIC AND HARDER PROBLEMS IN CHEMISTRY

It is well known that some students are good problem solvers while others are poor ones. In turn, the problems to be dealt with could be generic (standard) or non generic (harder) problems.

4.1. Generic Problems and Developing Their Algorithms

Generic problems are standard problems that students are expected to master. A generic problem may be solved by use of an algorithm, a series of steps that are performed, in sequence, to accomplish the goal of the problem. Here are examples of generic problems:

Problem 1: How many kilometres is equivalent to 16 miles?

Problem 2: How many moles of gas at S.T.P. is equivalent to 6.02×10^{23} molecules?

These are conversion factor problems. All members of this class have the form:

Given a measurement of a quantity, transform the description into an alternative, but equivalent description of the quantity.

In such a case students are expected to use a standard process, an algorithm, to solve the problem rather than creating a unique process to solve it. One algorithm for solving conversion factor problems is the factor label method or dimensional analysis, and this will be illustrated below.

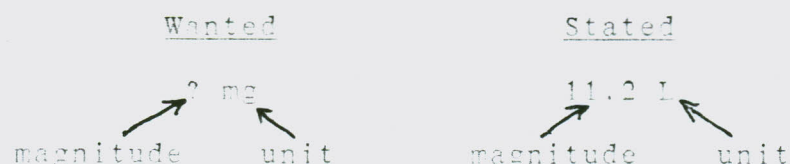
Problem 3: How many milligrams 11.2 litres of oxygen gas weigh at S.T.P.? (32 gram of oxygen = 22.4 L of oxygen at S.T.P.)

Algorithm: The factor label algorithm for conversion factor problems.

Step 1: Identify the Problem Situation.

The problem is about a quantity of oxygen gas. Students need to form an image (on paper or in their mind) of the situation described in the problem.

Step 2: Identify the Stated and Wanted Descriptions.



Step 3: Equate the Wanted and Stated Descriptions.

$$? \text{ mg} = 11.2 \text{ L}$$

Step 4: Analyze the Wanted and Stated Descriptions for Properties and Systems of Measurement.

$$? \text{ mg} = 11.2 \text{ L}$$

metric mass metric volume

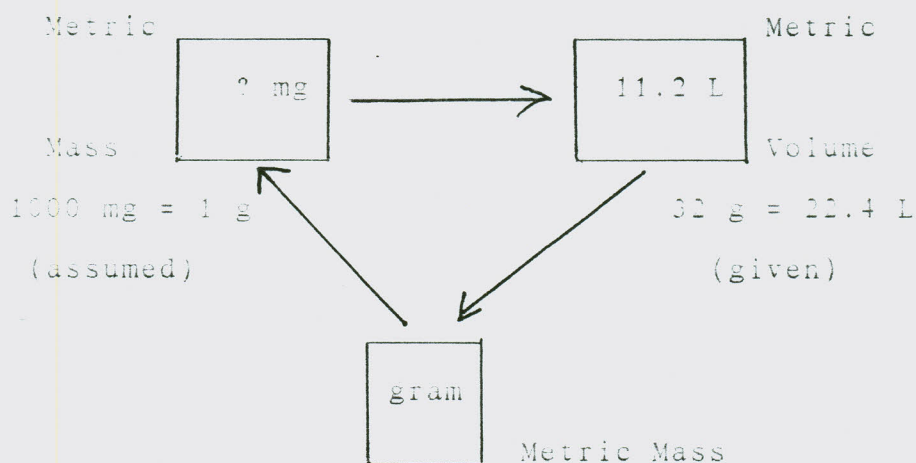
This key step abstracts the nature of the conversion, i.e., what properties are to be transformed. A prerequisite skill is the ability of students to identify which property is described by each unit. For instance, litre (L) must be recognized as a unit that measures the property of volume of gas in the metric system.

Step 5: Find and Analyze Conversion Factors in the Problem.

$$32 \text{ g of oxygen} = 22.4 \text{ L oxygen}$$

metric mass metric volume

Step 6: Plot the Solution Path



In this example, the student must supply from memory the gram-to-milligram conversion factor to end with the mass unit required by the problem.

Step 7: Multiply the Stated Description by the Required Conversion Factor.

$$? \text{ mg} = 11.2 \text{ L} \times \frac{32 \text{ g}}{22.4 \text{ L}} \times \frac{1000 \text{ mg}}{1 \text{ g}}$$

Errors in writing conversion factors upside-down are self-correcting.

Step 8: Compute the Final Answer.

$$? \text{ mg} = 16000 \text{ mg}$$

Students must compute accurately and check for correct units and number of significant figures (when necessary).

As students become more accomplished problem solvers, short cuts and omissions must be justified.

4.2. Instructional Sequences for Teaching an Algorithm

If an algorithm is to be useful, students must know when it should and should not be used. For example, the conversion factor algorithm is used in the case of problem 3. However, a problem might identify three properties of a gas sample (example, P,n,T) and ask for the value of a fourth property (V). Such a problem would not use the conversion factor algorithm, but a mathematical formula algorithm, since the formula $PV = nRT$ relates these four variables.

In order to directly attack the question of when to use an algorithm, the following possible instructional sequences for teaching are suggested:

1. Confront students with multiple examples of the generic problem; discuss the similarities and differences of these problems.
2. Present the algorithm in written outline form to give

students an overview of the solution process.

3. Work through the algorithm using a simple example, discuss how to perform each step and its rationale.
4. Review, as necessary, the prerequisite information and skills needed for each step.
5. Give students practice in using the algorithm to solve two or three relevant problems without assistance.
6. Discuss contexts in which the algorithm can and cannot be used, using examples when appropriate.

4.3 Harder (Non generic) Problems and Extending Algorithms

A non generic (i.e., harder) problems can be illustrated by the following conversion factor problem:

Problem 4: The heat of combustion of one mole of acetylene is -1300 KJ/mole . How many grams of CO_2 would be produced by combustion reaction that evolved 675 KJ ?

The solution to the above problem requires more than a straight forward use of the appropriate algorithm: the student should write the correct equation for the combustion, form a conversion factor linking amount of heat and amount of CO_2 , and then apply the factor label algorithm correctly. While dealing with more difficult problems, the student will also be required to combine algorithms, alter a step within the algorithm, or extend the algorithm to a new context. It's also recognized that students (particularly weaker students) will require more direct teaching when confronted with nonstandard problems. Therefore, the following are possible sequence of activities:

1. Presentation and mastery of the basic algorithm.
2. Confrontation with problems that have a single difference from the standard problem.
3. Instructor explication of the adaptations needed.
4. Student-generated adaptations on a new set of problem.
5. Confrontation with problems that have multiple differences from the standard problem.
6. Instructor/student-generated adaptations.

For example, conversion factor may be hidden within prose statements (as in problem 5):

Problem 5: The maximum amount of NaCl that can be dissolved in 100mL of water at 0.00°C is 35.7g. What volume of saturated NaCl solution at this temperature would be obtained from the complete dissolution of 72.3g of this salt?

The equality, 100mL = 35.7g NaCl, is contained within the first sentence. Therefore, there is a need for practice, on the part of the students, in writing verbal equivalencies first in equation form and then in conversion factor form. In practising this skill, students need not solve the entire problem. Also give students. Also give students practice in translating conversion factors into words.

GLOSSARY

1. Algorithm:- a series of steps that are performed, in sequence, to accomplish the goal or objectives of a problem.
2. Generic Problem:- a standard problem. Such a problem does not require the student to extend a formula or a

series of steps (an algorithm) in order to master the problem.

3. Guided Practice:- one form of activities of lessons in which the teacher directly controls the students activities by giving examples, asking a number of questions, etc.
4. Higher- Order Questions:- questions which require the student to use the information he has in order to provide an answer which differs in form and organization from the form in which it was previously taught. For example, the student may be required to change the form of the information or facts in order to compare, contrast, analyze, evaluate, etc.
5. Independent Practice or Seatwork:- one form of the activities of the lessons in which the students are engaged in assigned exercises, practical work, or study. In this case the teacher's control is indirect, as opposed to guided practice. The teacher may circulate during seatwork and may have short contacts with individual students.
6. Lower-Order Questions:- Questions which require the student to recall specific facts or information which were previously taught.
7. Teacher Effectiveness:- Refers to the ability of a classroom teacher to produce higher-than-predicted gains on student achievement tests.

2. Presentation of

Development

- 2.1 Did the teacher provide short statement of objectives?
- 2.2 Did the teacher highlight main points?
- 2.3 Did the teacher provide illustrations and concrete examples?
- 2.4 Did the teacher use demonstrations and models during presentation?
- 2.5 Did the teacher start with simple examples followed by more complex ones?
- 2.6 Did the teacher make digressions?
- 2.7 Did the teacher use ambiguous phrases and pronouns?
- 2.8 Did the teacher use step-by-step presentation?
- 2.9 Did the teacher give explicitly step-by-step directions?
- 2.10 Did the teacher present an outline?
- 2.11 Did the teacher give detailed and repeated explanations?
- 2.12 Did the teacher make students summarize the main points in their own words?
- 2.13 Did the teacher ask questions without chance for pupils to answer?
- 2.14 Did the teacher use unnecessary technical terms?
- 2.15 Did the teacher use unexplained difficult vocabulary?
- 2.16 Did the teacher use algorithms while dealing with generic problems?
- 2.17 Did the teacher extend algorithms while dealing with non-generic problems?

3. Guided Practice

- 3.1 Did the teacher ask questions with in guided practice?
- 3.2 Were the questions relevant to the content or skill?
- 3.3 Did the teacher check for understanding by evaluating student responses?
- 3.4 Did the teacher give additional explanations or process feedback during CFU?
- 3.5 Did the teacher provide prompts during guided practice?

4. Correctives and Feedback

- 4.1 Did the teacher ask another question after correct responses?
- 4.2 Did the teacher provide short statement of correctness after correct responses?
- 4.3 Did the teacher provide process feedback after hesitant correct responses?
- 4.4 Did the teacher try to elicit and improved response when the one is incorrect?
- 4.5 Did the teacher ask pupils to give an example illustrating the content being taught?
- 4.6 Did the teacher provide specific praise?

5. Independent Practice or

Seatwork

- 5.1 Did the seatwork activity follow immediately after guided practice?
- 5.2 Where the exercises directly relevant to demonstrations and guided practice activities?
- 5.3 Did the teacher guide students through the first few seatwork problems?
- 5.4 Did the teacher circulate among the students during seatwork.
- 5.5 Did the teacher make more than 30 seconds contact with individual students?
- 5.6 Did the teacher establish a routine to use during seatwork?

6. Weekly and Monthly Reviews

- 6.1 Did the teacher conduct weekly reviews?
- 6.2 Did weekly reviews focus on concepts and skills taught in the previous week?
- 6.3 Did the teacher conduct monthly reviews?
- 6.4 Did monthly reviews focus on concepts and skills taught since last monthly review?

Appendix III

Grade 11 - Chemistry

The Grid (Test Specification)

C O N T E N T				
	Area A	Area B	Area C	Area D
Behavioral Objectives	Conditions for reaction to occur, energy of reactions; factors that effect the rates of chemical reactions	Reverse-able reactions and chemical equilib-rium; The Principle of Le Chateler;	Catalysts of Enzymes	General Properties of metals; product-ion and uses of metals; Alloys
I. Fact or informa- tion	Items	Items	Items	Items
1. Knowledge of important fact	2	1	2	17.2 , 22
2. Knowledge of definitions of important terms			9	
3. Acquaintance with important concepts	23	14		
4. General knowledge of the physical and chemical properties of substances				15.1
5. Knowledge of methods and procedures		13		25
I. Comprehension or Understanding				
1. Ability to interpret verbal material		12.19		
2. Ability to interpret				

charts and diagrams	3,4,5,6,7	
3. Ability to translate verbal materials to mathematical formulas		18
4. Ability to predict future cons- equences implied in a data		20
5. Ability to justify methods and procedures		24
6. Ability to identify or give examples of concepts & principles	10,11	

Appendix IV

Chemistry test for Grade 11

I. Choose the best answer and write the letter of your choice in the space provided.

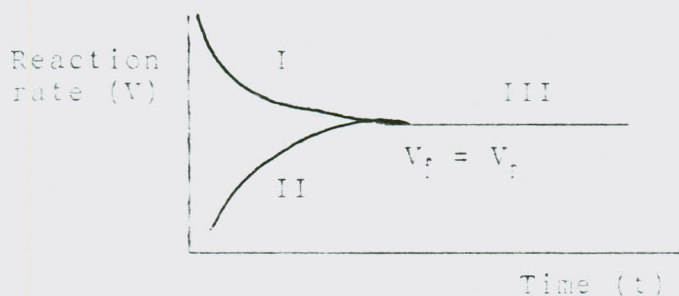
_____ 1. When did Le Chatelier formulate his principle?

- (a) 1688 (b) 1788 (c) 1888 (d) 1988

_____ 2. What is the name of the catalyst used in the production of ammonia from hydrogen and oxygen?

- (a) Iron (II) oxide (b) Potassium dichromat
(c) Platinum (d) Manganese dioxide

Answer questions 3 to 7 based on the following graphs.



V_f = rate of forward reaction

V_r = rate of reverse reaction

Fig. 2 Reaction rates and their variation in time for a general reaction of the type $A + B \rightleftharpoons C + D$

_____ 3. The variation of the rate of the forward reaction with time is represented by the graph (s):

- a. I b. II
c. both I and II d. neither I nor II

_____ 4. The variation of the rate of the reverse reaction with time is represented by the graph (s):

- a. I b. II
c. both I and II d. neither I nor II

- _____ 5. The forward reaction could be represented by the chemical equation:
- a. $A + B \xrightarrow{V_f} C + D$ b. $C + D \xrightarrow{V_f} A + B$
 c. $A + B \xrightarrow{V_r} C + D$ d. $C + D \xrightarrow{V_r} A + B$
- _____ 6. Will the forward reaction have a very high rate at the beginning of the reaction? Why?
- a. Yes, because the concentration of the products is much higher than that of the reactants.
 b. No, because the concentration of the reactants is much higher than that of the products.
 c. Yes, because the concentration of the reactants is much higher than the products.
 d. No, because the concentration of the products is much higher than the reactants.
- _____ 7. By the time $V_f = V_r$ (Graph III), the system:
- a. Necessarily contains either the reactants only or the products only.
 b. Is at a static equilibrium
 c. Necessarily contains equal percentage of the reactants and the products.
 d. Is at a dynamic equilibrium.
- _____ 8. One of the following is not a necessary condition for a chemical reaction to occur:
- a. catalyst b. collision
 c. activation energy d. proper orientation
- _____ 9. Which one of the following best defines the term positive catalyst ? It is a substance that:
- a. affects the rate of a reaction without itself

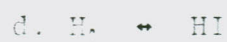
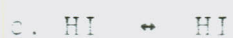
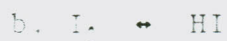
appearing in the product.

b. slow down the rate of a reaction without itself appearing in the product.

c. decrease the reaction rate by helping the reaction to reach equilibrium slower.

d. speed up the reaction rate by helping the reaction to reach equilibrium faster.

____ 10. Which one of the following best illustrates the concept of effective collision for the reaction:



____ 11. Which one of the following is an example of exothermic reaction?



a. only I

b. only II

c. both I and II

d. neither I nor II

____ 12. There is an increased quantity of CO produced when coal is burned in a limited supply of oxygen.

This is so because

a. C reacts with CO

b. C reacts with CO_2

c. CO is an effective reducing agent

d. greater oxidation takes place

____ 13. If you were preparing carbon monoxide (CO) from coal (C) and carbondioxide (CO_2), which one of the following could not be your activity?

- a. First heating CO_2 in the tube until it is red-hot
 - b. First heating C in the tube until it is red-hot
 - c. Passing CO_2 over the coal while heating the tube
 - d. Taking care of the poisonous and flammable CO gas
- ____ 14. Which one of the following is not a characteristic of a system at chemical equilibrium?
- a. The system is at a dynamic process
 - b. There is no net change in the composition of the system
 - c. The forward and reverse reaction rates are equal
 - d. The actual forward and reverse reactions have stopped
- ____ 15. Suppose element X is a metal. It is a liquid at ordinary temperature. It is chiefly found in the form of cinnabar. It is an element of group IB. Element X is:
- a. Mercury
 - b. Silver
 - c. Copper
 - d. Bromine
- ____ 16. A substance consists of two or more metallic elements or of metallic and non-metallic elements. These elements are soluble in each other when solid. The general name for such a substance is:
- a. electrolyte
 - b. ore
 - c. isomer
 - d. alloy
- ____ 17. The chemical formula for rock salt is:
- a. AlCl_3
 - b. $\text{KCl} \cdot \text{NaCl}$
 - c. NaCl
 - d. $\text{AlCl}_3 \cdot \text{KCl}$
- ____ 18. Which one of the following is true of 32 g of oxygen gas?
- a. It contains 6.02×10^{23} atoms of oxygen.

- b. It contains 6.02×10^{23} molecules of oxygen.
- c. It contains 2 moles of oxygen.
- d. It occupies 44.8 litres of oxygen at STB.

- ____ 19. Do 6.02×10^{23} particles of each gas occupy the same volume at STP? Why?
- a. Yes, because they have different number of molecules.
 - b. No, because they have different masses.
 - c. Yes, because they have the same number of moles
 - d. No, because they have the same number of molecules.

- ____ 20. The following system is in equilibrium at a high temperature:



What will be the result if the pressure on the system is increased?

- a. The amount of H_2 and N_2 will increase
 - b. The amount of NH_3 will increase
 - c. The amount of all three substances will increase
 - d. The reaction will go to completion to the right.
- ____ 21. The starting material for the production of elementary calcium is:
- a. fused calcium bicarbonate
 - b. fused calcium carbide
 - c. fused calcium chloride
 - d. fused calcium oxide.
- ____ 22. Brass is made up of:
- a. Cu and Sn
 - b. Cu and Zn
 - c. Sn and Zn
 - d. Cu, Zn and Sn

- ____ 23. Which one is the correct statement about exothermic reactions?
- a. Absorption of energy will take place
 - b. An increase in temperature will slow down the rate.
 - c. An increase in temperature will speed up the rate.
 - d. Temperature will not have any effect on the rate.
- ____ 24. Why is platinum (Pt) used in the decomposition of hydrogen peroxide (H_2O_2) to water (H_2O) and oxygen gas (O_2)?
- a. It removes the impurities from H_2O_2 .
 - b. It increases the reaction rate of H_2O_2 .
 - c. It increases the proper orientation of H_2O_2 .
 - d. It increases the concentration of H_2O_2 .
- ____ 25. Given the following two reactions:



Identify the overall balanced chemical reaction!

- a. $\text{Cu} + \text{CuO} + 2\text{H}_2\text{SO}_4 \rightarrow \text{CuSO}_4 + \text{SO}_2 + 2\text{H}_2\text{O}$
- b. $2\text{Cu} + 2\text{H}_2\text{SO}_4 \rightarrow \text{CuSO}_4 + \text{SO}_2 + \text{CuO} + \text{H}_2\text{O}$
- c. $\text{Cu} + 2\text{H}_2\text{SO}_4 \rightarrow \text{CuSO}_4 + \text{SO}_2 + 2\text{H}_2\text{O}$
- d. $\text{CuO} + \text{H}_2\text{SO}_4 \rightarrow \text{CuSO}_4 + \text{H}_2\text{O}$

Declaration

The thesis is my original work, has not been presented for a degree in any other University and that all sources of material used for the thesis have been duly acknowledged.

A handwritten signature in cursive script, appearing to read 'Temechegn Engida', written over a horizontal line.

Temechegn Engida