A MASTERY LEARNING PLAN IN CHEMISTRY

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by

Mithal D. Patel

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ABSTRACT

The decreasing enrollment in senior chemistry courses as well as the learning difficulties encountered by many students were the major factors for embarking on this study. Because students' learning difficulties, can be shown to be related to teaching strategies, an effort was made to develop a more effective teaching plan in order to reduce the students' learning difficulties. The Mastery Learning Plan, a teaching strategy, was thus developed. The purpose of this study was to develop and to then evaluate the effect of the Mastery Learning Plan on achievement and attitude towards the learning of chemistry.

A control group consisting of twenty-three students and an experimental group consisting of sixteen students were involved in the evaluation of the Mastery Learning Plan. The control group was taught the Chemistry 200 course according to the traditional learning procedure while the experimental group was taught according to the Mastery Learning Plan. Both groups were given pre and post achievement and attitude tests in chemistry. An independent t-test was used to compare the achievement and attitude of the two groups of students.

A statistical analysis of the data provided descriptive information about the control and experimental group's achievement and attitude. It was found that the

control and experimental groups were comparable in terms of achievement and attitude at the beginning of the semester. However, at the end of the semester it was found that the experimental group scored significantly higher than the control group in achievement and attitude towards the learning of chemistry.

On the basis of this evidence, it was concluded that the Mastery Learning Plan appeared to have enhanced student achievement and attitude towards the learning of chemistry. Furthermore, in the control group there was eleven per cent of the students who discontinued their study of chemistry in the middle of the semester; whereas zero per cent of students discontinued their study in the experimental group. In the control group only fifty-seven per cent of the students registered for Chemistry 300 course; whereas one hundred per cent of students in the experimental group registered for Chemistry 300 course. It was therefore recommended that the Mastery Learning Plan be considered as a possible teaching strategy by other teachers of Chemistry 200.

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INTRODUCTION

INTRODUCTION

The "post-sputnik" era produced many changes in Western society. It has created an exponential increase in knowledge and skill, and computerization of many facets of our society has produced special problems for mankind. This knowledge explosion as well as computerization demands that young and old alike must have the desire and the ability to acquire new and different knowledge during their life times. Professor Benjamin Bloom points out that "Increasingly, learning throughout life (continuing learning) will be necessary for the largest proportion of the work force."[1]

The educational system is an instrument to serve the needs of society, and as such, must not ignore the present and the future needs of society. These needs can be met by producing students who have the desire and the ability to be trained and if necessary retrained. This implies that the school system must find ways to bring successful learning experiences to the maximum number of

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[1]Benjamin S. Bloom, "Learning for Mastery," Evaluation Comment, (U.C.L.A., CSEP, Vol. I, No. 2, May, 1968), p. 2.

students. There are many well established psychological studies that support the fact that the desire to learn is a function of the past successful learning experiences.[2] The school system must find instructional strategies which can maximize successful learning experiences to the maximum number of students. This is supported by Benjamin Bloom when he states:

> The basic problem is to determine how the largest proportion of the age group can learn effectively ... If school learning is regarded as frustrating and even impossible by a sizeable proportion of students, then little can be done at later levels to kindle a genuine interest in further learning. School learning must be successful and rewarding as one basis for insuring that learning can continue throughout one's life time.[3]

An instructional model must be created to produce the desired effect within the present economic and physical framework of the school. There are large numbers of theoretical instructional strategies gathering dust on various library shelves, due to the fact that their implementation requires a major overhaul in the present human and physical resources of the school. This study is in response to the search for an instructional model which will facilitate learning within the framework of the traditional classroom setting.

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[2] Pauline S. Sears, "Levels of Aspiration in Academically Successful and Unsuccessful Children," Journal of Abnormal Social Psychology, Vol. XXXV., (October, 1940), pp. 498-536.

[3] Bloom, op. cit., p. 2.

RATIONALE FOR THE STUDY

Past teaching experience shows that all is not well with our current group instructional practices. This statement is based on the author's observation of the following:

(1) The boredom of gifted students.

(2) The drop out of students.

(3) The plight of persevering students who are hopelessly trying to cope with the learning of complex concepts without an adequate background of previous concepts.

(4) The decreasing enrollment in senior Chemistry courses.

(5) The hostility exhibited by many students towards learning per se.

Kemp made similar observations of the teaching-learning situation. These observations led him to formulate the following questions:

> Why do students find much of the materials that they are assigned to learn to be irrelevant to them?
>
> Why are students often bored by the ways they are taught?
>
> How can we do a better job of serving the individual needs of students?
>
> What should be my role in improving instruction?
>
> Is there a better way to plan for effective instruction?
>
> Can education really be improved within the

> limitations of available funds, personnel, and facilities?[4]

The search for a suitable answer to questions such as these requires a detailed examination of the teaching-learning situation.

According to Bruner,[5] instruction should provide the learner with a favorable disposition towards learning, "optimal-structure", effective sequential arrangement of knowledge, and the nature and types of reinforcement which will enhance learning. Learning according to Carroll, "is an act which leads a person from one state of knowledge or skill to another state of knowledge or skill."[6] Further, Carroll believes that "nearly all pupils can learn what they are supposed to learn given enough time."[7] Carroll views teaching "as a process concerned with the management of learning."[8] The work of Carroll, Kemp, Bruner, and Bloom as well as the author's observation of the students' plight has been a motivating factor in his embarking on this research.

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[4]Jerrold E. Kemp, Instructional Design, (Fearon publ., Belmont, Ca., 1971), p. 3.

[5]Jerome S. Bruner, Toward a Theory of Instruction, (Harvard University Press, Cambridge, Massachusetts, 1966), pp. 401-453.

[6]John B. Carroll, "Problems of Measurement Related to the Concept of Learning for Mastery," Educational Horizons, (Vol. IIL, No. 3, 1970), pp. 71-72.

[7]Ibid.

[8]Ibid.

Personal observation has led to the conclusion that students entering in Chemistry 200 have shown basic interest and ability to learn Chemistry. The fact that students found it difficult to continue their study of Chemistry was the motivating force behind the Mastery Learning Plan.

This fact necessitated the examination of teaching strategies. This examination revealed that the classroom instruction was geared to an average learner. No major consideration was given to below average or above average learner. This examination suggests that this phenomenon, that is, directing of instruction to average learner may have been responsible for the failure of current teaching practices. The author participated in a pilot project which attempted to provide for the needs of the fast and slow learners. This project assumed that the teaching strategy should include the following:

(1) The content must be sequentially structured.

(2) There must be provisions for variety of learning experiences.

(3) Considerations must be given to time required by fast and slow learners.

(4) Considerations must be given to the readiness of the learners to accept new knowledge.

Approximately eighty Grade X students of the Innisfail High School were exposed to a Mastery Learning Plan in Chemistry without its experimental rigor. This Chemistry course was the first course in the secondary school program as outlined by the Curriculum Branch of the Department of Education of Alberta. The students came from rural and farm communities. The program was prematurely terminated due to certain administrative as well as political decisions. The encouraging responses from the students and parents were motivating forces behind the development of the Mastery Learning Plan.

STATEMENT OF THE PROBLEM

The purpose of the study was to develop and evaluate the effect of a Mastery Learning Plan on the student's achievement and attitude towards the learning of Chemistry. The study will compare the effectiveness of two different instructional programs; a traditional learning procedure will be compared with a teacher developed Mastery Learning Plan. The comparison will be in terms of student achievement and student attitudes towards the learning of Chemistry.

During the course of this research the following questions were addressed:

(1) Is there a difference in achievement in Chemistry between the student who experiences the Mastery Learning Plan and the student who follows the traditional learning procedure?

(2) Is there a difference in student attitudes between the student who experiences the Mastery Learning Plan and the student who follows a traditional learning procedure?

(3) Is there a difference in achievement between high IQ and low IQ students who experience the Mastery Learning Plan?

(4) Is there a difference in attitude toward the learning of Chemistry between high IQ and low IQ students who experience the Mastery Learning Plan?

(5) Is there a difference in achievement between high IQ and low IQ students who experience the traditional learning procedure?

(6) Is there a difference in attitude towards the learning of Chemistry between high IQ and low IQ students who follow the traditional learning procedure?

HYPOTHESES

Ho_1 : There will be no statistically significant difference in mean scores of student achievement, as measured by the pre-test, between the experimental and the control groups.

$$Ho_1 : \mu_{EG} = \mu_{CG}$$

$$H1_1 : \mu_{EG} \neq \mu_{CG}$$

Ho_2 : There will be no statistically significant difference in mean scores of student attitude towards the learning of Chemistry, as measured by the pre-attitude test, between the experimental and the control groups.

$$Ho_2 : \mu_{EG} = \mu_{CG}$$
$$H1_2 : \mu_{EG} \neq \mu_{CG}$$

Ho_3 : There will be no statistically significant difference in student IQs as measured by the Otis Beta test, between the experimental and the control groups.

$$Ho_3 : \mu_{EG} = \mu_{CG}$$
$$H1_3 : \mu_{EG} \neq \mu_{CG}$$

Ho_4 : There will be no statistically significant difference in the chronological ages between the experimental and the control groups.

$$Ho_4 : \mu_{EG} = \mu_{CG}$$
$$H1_4 : \mu_{EG} \neq \mu_{CG}$$

Ho_5 : There will be no statistically significant difference in mean scores of student achievement, as measured by the post test, between the experimental and the control groups.

$$Ho_5 : \mu_{EG} = \mu_{CG}$$
$$H1_5 : \mu_{EG} \neq \mu_{CG}$$

Ho_6 : There will be no statistically significant difference in mean scores of student attitude towards the learning of Chemistry, as measured by the post attitude test, between the experimental and the control groups.

Ho_6 : $\mu_{EG} = \mu_{CG}$

$H1_6$: $\mu_{EG} \neq \mu_{CG}$

Ho_7 : There will be no statistically significant difference in mean scores of student achievement, as measured by pre and post test, of high IQ students of the experimental group.

Ho_7 : μ pre-achievement of high IQ of EG $=$ μ post-achievement of high IQ of EG

$H1_7$: μ pre-achievement of high IQ of EG $\neq$ μ post-achievement of high IQ of EG

Ho_8 : There will be no statistically significant difference in mean scores of student achievement, as measured by pre and post test scores, of low IQ students of the experimental group.

Ho_8 : μ pre-achievement of low IQ of EG $=$ μ post-achievement of low IQ of EG

$H1_8$: μ pre-achievement of low IQ of EG $\neq$ μ post-achievement of low IQ of EG

Ho_9 : There will be no statistically significant difference in mean scores of student attitude towards the learning of Chemistry, as measured by pre and post attitude test, of high IQ students of the experimental group.

Ho_9 : μ pre-attitude of high IQ of EG = μ post-attidude of high IQ of EG

$H1_9$: μ pre-attidude of high IQ of EG $\neq$ μ post-attidude of high IQ of EG

Ho_{10} : There will be no statistically significant difference in mean scores of student attidude toward the learning of Chemistry, as measured by pre and post attitude test, of low IQ students of the experimental group.

Ho_{10} : μ pre-attidude of low IQ of EG = μ post-attitude of low IQ of EG

pre-attitude of low IQ of EG $\neq$ post-attitude of low IQ of EG

Ho_{11} : There will be no statistically significant difference in mean scores of student achievement, as measured by pre and post test scores, of high IQ students of the control group.

$$Ho_{11} : \mu_{\text{pre-achievement of high IQ of CG}} = \mu_{\text{post-achievement of high IQ of CG}}$$

$$H1_{11} : \mu_{\text{pre-achievement of high IQ of CG}} \neq \mu_{\text{post-achievement of high IQ of CG}}$$

Ho_{12} : There will be no statistically significant difference in mean scores of student achievement, as measured by pre and post test scores, of low IQ students of the control group.

$$Ho_{12} : \mu_{\text{pre-achievement of low IQ of CG}} = \mu_{\text{post-achievement of low IQ of CG}}$$

$$H1_{12} : \mu_{\text{pre-achievement of low IQ of CG}} \neq \mu_{\text{post-achievement of low IQ of CG}}$$

Ho_{13} : There will be no statistically significant difference in mean scores of student attitude towards the learning of Chemistry, as measured by pre and post attitude test, of high IQ students of the control group.

$$Ho_{13} : \mu_{\text{pre-attitude of high IQ of CG}} = \mu_{\text{post-attitude of high IQ of CG}}$$

$H1_{13}$: μ pre-attitude of high IQ of CG $\neq$ μ post-attitude of high IQ of CG

Ho_{14} : There will be no statistically significant difference in mean scores of student attitude towards the learning of Chemistry, as measured by the pre and post attitude test, of low IQ students of the control group.

Ho_{14} : μ pre-attitude of low IQ of CG $=$ μ post-attitude of low IQ of CG

$H1_{14}$: μ pre-attitude of low IQ of CG $\neq$ μ post-attitude of low IQ of CG

DEFINITION OF TERMS

The Traditional Learning Procedure

The traditional learning procedure refers to a method of teaching in which instruction is geared to the average learner. Furthermore the rate of learning is fixed for all students. Interactions in the traditional learning procedure are primarily between the teacher and students. On certain occasions a teacher using the traditional learning procedure may offer remedial or enrichment instruction to meet the needs of individual students. However, this decision is solely made by the teacher.

Consult Figure 1 for day to day classroom decisions in the traditional learning procedure.

The Mastery Learning Plan

The Mastery Learning Plan refers to a method of teaching in which instruction is geared to the individual student. In the Mastery Learning Plan the rate of learning varies with the individual student. Furthermore, interactions in the Mastery Learning Plan are varied and complex. There are ample opportunities for interactions between student and student as well as between teacher and student. A more comprehensive picture of the Mastery Learning Plan can best be obtained by considering the role of the teacher and the pupil in the making of day to day decisions regarding classroom activities. Consult Figure 1, page 14.

Average Learner

An average learner is defined as a learner whose time for acquiring a concept or skill is the same as the time required by his teacher to teach the same concept or skill to the majority in his class group. That is, an average learner is a student whose rate of learning a concept or a skill is the same as the rate of teaching of that concept or skill by a teacher to the majority in his class.

Slow Learner

A slow learner is defined as a learner whose time for acquiring a concept or skill is more than the time

Activity	The traditional learning procedure Decisions made by:	A Mastery Learning Plan Decisions made by:
1. Which skill or concept to be learned	Teacher	Student
2. Which assignment to be completed	Teacher	Student
3. Which laboratory activity to be done	Teacher	Student
4. To provide remedial instruction	Teacher	Student and/or Teacher
5. To provide enrichment activity	Teacher	Student and/or Teacher
6. Rate of learning	Teacher	Teacher and Student
7. Time to write self-test	None	Student
8. Time to write unit test	Teacher	Student
9. Review and discussion of principles of Chemistry	Teacher	Teacher
10. Overall content of the Chemistry 200 program	Curriculum Branch of Dept. of Education	Curriculum Branch of Dept. of Education

Figure 1

The Day to Day Classroom Decisions

required by an average learner. That is, a slow learner is a student whose rate of learning a concept or skill is less than the rate of teaching of that concept or skill by a teacher to an average learner.

Fast Learner

A fast learner is defined as a learner whose time for acquiring a concept or skill is less than the time required by a teacher to teach the same concept or skill to an average learner. That is, a fast learner is a student whose rate of learning a concept or skill is greater than the rate of teaching of that concept or skill by a teacher to an average learner.

Chemistry 200

Chemistry 200 is the course name for the Chemistry program which was authorized for Grade 11 by the Department of Education of the Province of Manitoba.

Experimental Group

The experimental group is defined as the students who experienced the Mastery Learning Plan.

Control Group

The control group is defined as the students who experienced the traditional learning procedure.

High IQ Student

High IQ student is defined as a student whose IQ score, as measured by Otis beta IQ test, is greater than 110.

Low IQ Student

Low IQ student is defined as a student whose IQ score, as measured by Otis Beta IQ test, is less than or equal to 110.

ASSUMPTIONS

It was assumed that the achievement tests used in the study was valid. Consult Appendix D. It was also assumed that the results obtained were not affected by the teacher's enthusiasm or lack of enthusiasm towards a method of instruction. It was further assumed that the students were not aware of their involvement in this study. The decision as to which group in the semester system to be taught by the traditional learning procuedure or by Mastery Learning Plan was made prior to any knowledge of the make up of the class. That is, there was no pre-selection of students or method of instruction.

It was further assumed that all students had the necessary ability and experience to deal effectively with multiple choice type of questions. The necessary safeguards were taken to assure that none of the students had previous exposure to any of the test items. Finally, it was assumed that all tests were properly administered with respect to time.

LIMITATIONS

The limitations to the study are:

(1) The study was conducted for a period of one academic year.

(2) The study was conducted in one school .

(3) The samples consisted of thirty-nine students.

(4) Both the traditional learning procedure as well as the Mastery Learning Plan were taught primarily by the author. However, the Mastery Learning Plan was taught by a student teacher for a period of five weeks. The Mastery Learning Plan was used by a teacher, Mr. M. Goldberg, during the 1974-1975 academic year. Consult Appendix F for Mr. Goldberg's appraisal of the Mastery Learning Plan.

Chapter 2

REVIEW OF LITERATURE

HISTORY

The idea of Mastery Learning has its roots in educational history as far back as the 1920's. Post World War I was an era of rapid social and technological change. It was during this historical setting that Carelton Washburne and his associates embarked on an instructional innovation called the Winnetka Plan (1922). Later on in the same decade Professor Henry C. Morrison developed a plan called the Laboratory School (1926). The basic features of the two plans as stated by James E. Block are:

> First, Mastery was defined in terms of particular educational objectives each student was expected to achieve. The objectives were cognitive for Washburne and cognitive, affective and even psychomotor for Morrison. Second, instruction was organized into well-defined learning units ... Third, complete mastery of each unit was required of students before proceeding to the next ...
>
> Fourth, an upgraded, diagnostic progress test was administered at the completion of each unit to provide feed back on the adequacy of the student's learning ... Fifth, on the basis of this diagnostic information, each student's original instruction was supplemented with appropriate learning correctives so that he could complete his unit learning ... Finally, time was used as a variable in individualizing instruction ... Under Morrison's method each student was allowed the learning time his teacher required to bring all or almost all students to

unit mastery.[9]

The Mastery Learning Plans of Morrison and Washburne flourished for about a decade, but then the plans disappeared due to lack of material and human resources. The dictates of economics took their final toll on the two Mastery Learning Plans in the 1930's. According to James E. Block[10] the idea of the unit learning plan reappeared in the disguise of B.F. Skinner's Programmed Instruction in the 1960's, the basic theory being that learning progresses from simpler tasks to more complex tasks. The basic theory as advocated by Washburne et al and Morrison was and is still sound, but its implementation required additional human and material resources which the pundits of society were reluctant to provide.

During the 1960's there were two major instructional innovations based on programmed instruction namely, Individually Prescribed Instruction (IPI) at Pittsburg and Computer Assisted Instruction (CAI) at Stanford. Both of these instructional innovations divided the course of study in sequentially arranged lessons. The IPI and CAI plans contained the variety of learning paths necessary for meeting the individual needs of the student. Also, each student's learning was monitored to provide the necessary feedback. Despite the tremendous effort on the

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[9] James E. Block, Mastery Learning, (Holt, Rinehart and Winston, Toronto, 1971), pp. 3-4.

[10] Ibid., p. 5.

part of the developers of the programs they failed to meet the needs of all of the students. That is:

> ... programmed instruction provided a valuable tool to help some students to attain mastery, it did not provide a useful mastery learning model.[11]

The partial failure of the programmed instruction may be due to the lack of group interaction. According to Richard and Patricia A. Schmuck, "Peers directly influence one another's information and attitudes toward success."[12] The peer group influence as indicated above is as important in learning as the need for a learner to do his task by himself; that is, perhaps the ideal situation would be the one which incorporates the group as well as individualized programmed instruction. Richard and Patricia A. Schmuck illustrate the difference between two types of learning environments as:

> To illustrate the groupness of classrooms, let us describe two quite different classes which are involved in learning a foreign language. One class uses an individualized programmed procedure; each is allowed to proceed at his own rate and in his own unique way. Each student is seated in his own separate booth ... In this second class, interpersonal contacts are paramount, and group processes are pervasive.
>
> Both of these classrooms are commonly found in American public schools. Perhaps the most typical classroom would combine both

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[11]Ibid.

[12]Richard A. Schmuck, and Patricia A. Schmuck, <u>Group Processes in the Classroom</u>, (Wm. C. Brown Company Publ., Dubuque, Iowa, 1971), pp. 4-5.

> procedures ... These two types of classes are not antithetical to each other.[13]

From the above quote it can be seen that there are certain merits in each of the two methods of instruction. The authors point out that the "most typical classroom would combine both procedures."[14]

The marriage of the two methods of instruction is seen in John B. Carroll's "Model of School Learning". In 1963 John B. Carroll proposed a strategy for Mastery Learning. The basic aim of this strategy is to provide successful learning experiences to 95% of the student body in a given class. Carroll believes that "the learner will succeed in learning a given task to the extent that he spends the amount of time that he needs to learn the task."[15] Further he states that if the students are normally distributed with respect to aptitude, and the quality of instruction is kept uniform for all learners, then there should be a correlation of + .70 or greater between aptitude and achievement. However, if the same students were provided with optimal quality instruction, then there should be a zero correlation between aptitude and achievement. Aptitude in Carroll's view, is the amount of time required for the learner to learn a concept or a

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[13]Ibid.

[14]John Carroll, "A Model of School Learning," Teachers College Record, (Vol. LXIV), pp. 723-733.

[15]Ibid.

skill. Aptitude is specific for particular kinds of learning. In summary, Carroll believes that almost all students can master a complex task provided that each learner receives "optimal quality instruction " and the necessary time needed to learn the concept or task.

In 1968 Bloom proposed an instructional strategy based on Carroll's "Model of School Learning". The basic variables of this instructional model are that Bloom's[16] strategy for mastery learning contains five basic variables:

(1) Mastery learning strategy must find ways to reduce the learning time required for slower students.

(2) The mastery learning strategy must develop ways to meet the learning needs suitable to the characteristics of the learner. That is, instruction must be such that it will "lead the learner through a sequence of statements and restatements of a problem or of knowledge that increases the learner's ability to grasp, transform, and transfer what he is learning."[17]

(3) Mastery learning strategy must suggest alternative methods and materials needed for learning. According to Bloom, "If a student can't learn in one way, he should be reassured that alternatives are available to him ...."[18]

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[16]Bloom, pp. 3-4.

[17]Bruner, p. 49.

[18]Bloom, pp. 5-8

(4) Mastery learning strategy must find ways to increase the chances of success in learning so that the student's perseverence is increased. Perseverence is defined "as the time the learner is willing to spend in learning."[19] Those students who have experienced more failures will likely spend less time on learning a task than those who have experienced successes; that is, perseverence is directly related to the past success or failure.

(5) Mastery learning strategy must allow students to learn at their own rate. Students with low aptitude are likely to require more learning time than students with high aptitudes. An instructional strategy must recognize the fact that students learn at different rates, and as such one must find ways to allow students to learn at their own rates within the context of school organization. The five variables can be adapted in any suitable way for mastery learning.

The Learning for Mastery approach has been tried in courses ranging from elementary to graduate levels. A modified version of Carroll's model of school learning has been used to teach graduate level courses in test theory at the University of Chicago. The overall outcome of this program is explained by Airasian as:

> First, the correlation between total hours of weekly study and achievement was slightly

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[19]Ibid.

> negative. The author attributes this finding to the effectiveness of the feedback system ... The diagnostic tests seemed to make all students use study time more efficiently ...[20]

Similarly, an introductory undergraduate course in Educational Psychology has been taught using the Mastery Learning approach. Biehler[21] reports that this program was most effective for students who are most likely to give up.

A course in Freshman Mathematics was taught using mastery learning strategy at Purdue University. Collins appraised the effect of this program as:

> In both modern Algebra and the Calculus courses, D and F grades were for all practical purposes eliminated for mastery students.[22]

A modern Mathematics course in Junior High School was taught using mastery learning strategy. The effect of this program was the D and F grades were completely eliminated. The author of this research states that, "The diagnostic problems and review prescriptions were so effective here that the alternate learning resources were

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[20]Peter W. Airasian, "An Application of a Modified Version of John Carroll's Model of School Learning" in <u>Mastery Learning</u>, by James E. Block, (Holt, Rinehart and Winston, Inc., Toronto, 1971), p. 98.

[21]Robert F. Biehler, "A First Attempt at a 'Learning for Mastery' Approach," <u>Educational Psychologist</u>, (Vol. VII, No. 3, 1970), pp. 7-9.

[22]Kenneth M. Collins, "A Strategy for Mastery Learning in Freshman Mathematics," in <u>Mastery Learning</u>, by James H. Block, (Holt, Rinehart and Winston, Inc., Toronto, 1971), p. 111.

apparently superfluous."[23]

The mastery learning approach was used in teaching a freshman Physics course. The findings of this research indicate that the experimental group using the mastery approach did as well on an achievement test as those taught by the lecture-discussion-demonstration method.[24] Similarly a fifth grade Arithmetic class was taught using the mastery learning approach. The result indicates that "there were significant increases in the proportion of experimental students (mastery class) attaining mastery compared to ... (control class) attaining mastery."[25] Results of the various programs indicate that mastery learning strategy is not restrictive to any particular grade or subject.

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[23]Ibid., p. 112.

[24]Ben A. Green, "A Self Paced Course in Freshman Physics," in Mastery Learning, by James H. Block, (Holt, Rinehart and Winston, Inc., Toronto, 1971), p. 120.

[25]Mildred E. Kersh, "A Strategy for Mastery Learning in Fifth Grade Arithmetic," (Unpublished Ph.D. dissertation, University of Chicago), in Mastery Learning, by James H. Block, (Holt, Rinehart and Winston, Inc., Toronto, 1971), p. 121

RATIONALE

Individual Differences

The need to change the traditional group instruction arose at the turn of this centruy when educational theorists began discovering the individual differences among students. Up to this time the curriculum and the method of instruction were fixed for all students. This is explained by Cronbach as:

> It was in the early years of this century that individual differences became a primary topic in educational theory. Until that time, there was largely a fixed curriculum starting with the common branches of knowledge, and, proceeding through an academic high school program and a college liberal arts program. Individual differences were taken into account chiefly by elimination of students. Less successful students (and those from poorer families) dropped out along the way.[26]

When the ability tests came into focus the instructional strategy was changed to adapt to the individual differences. The ability test was used to decide which students should follow which instructional path, that is, there were and still are two different types of instructional programs -- one for the "slow" learner and the other for the "fast" learner. The theory behind this approach is that every child has the right to proceed as

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[26] Lee J. Cronbach, "How Can Instruction be adapted to Individual Differences?" in Learning and Individual Differences by Robert M. Gagne (ed.), (Charles E. Merrill Books Inc., Columbus, Ohio, 1967), p. 24.

far in the academic world as his abilities will allow. Thus Cronbach summarizes this approach as:

> When the ability tests became available they were used by schools -- to put it bluntly -- to decide which pupils would be allowed to drop by the wayside or to vegetate in an undemanding 'slow' classroom and which should ... go on to higher education.[27]

The school, even up to today uses ability tests to brand students as slow or fast learners, or to put it bluntly, dumb and bright students. The ability tests and further development in the phychological theories relating to individual make-up, led to the development of various instructional strategies. In Table 2 (page68) is Cronbach's summary of instructional adaptations to individual differences.[28]

One of the currently used methods for helping students to overcome their learning difficulties is that of providing remedial help. Remedial help as an adaptation to meet the needs of the students is described in '3a' of Figure 2. Cronbach, however, views the remedial method as "hole patching". That is:

> Remedial work takes it for granted that the classroom work is largely a fixed program. Many a pupil needs help that the standard program does not give him, and supplementary instruction is therefore provided with the intention of repairing the gaps in skill and putting him back on the pace. That

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[27]Cronbach, ibid.

[28]Ibid.

Educational goals	Instructional treatment	Possible modifications to meet individual needs
Fixed	Fixed	1a. Alter duration of schooling by sequentail selection 1b. Train to criterion on any skill or topic, hence alter duration of instruction
Options	Fixed within an option	2a. Determine for each student his prospective adult role and provide a curriculum preparing for that role
Fixed within a course or program	Alternatives provided	3a. Provide remedial adjuncts to fixed "main track" instruction 3b. Teach different pupils by different methods

Figure 2

Patterns of Educational Adaptation
to Individual Differences

> is, to say, remedial instructional attempts to erase individual differences.
> ... This type of hole patching is not very interesting psychologically, and its value may be quite limited.[29]

John B. Carroll shows his disagreement with Cronbach's view on remedial help as:

> If we assume ... that aptitude is partly a matter of the possession of prerequisite knowledges and skills, or the lack thereof, Cronbach's 3a and 3b procedures really amount to the same thing -- i.e., determining which prerequisite skills and knowledge are lacking in the pupil and attempting to provide instruction is necessarily labeled as mere "hole patching".[30]

The Mastery Learning Plan, however, is based on the idea of meeting the needs of the student through remedial help. It is not correct to say now that the remedial method is "hole patching". Any reasonable instructional method which can alleviate the learners' difficulty is not necessarily "hole patching". The disagreement between Cronbach and Carroll shows that we have to continue in our search for the correct instructional methods to meet individual differences.

According to Cronbach's instructional modification 3b, the ideal way to erase individual differences is to match "instructional diet" with the student's "idiosyncratic, intellectual metabolism". In other words,

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[29] Cronbach, ibid., p. 27.

[30] John B. Carroll, "Instructional Methods and Individual Differences in Learning," in <u>Learning and Individual Differences</u> by Robert M. Gagne, (ed), (Charles E. Merrill Books Inc., Columbus, Ohio, 1967), p. 42.

there should be a unique instructional method for each and every student. John B. Carroll, however, points out that an effort to accommodate individual differences by matching instructional method to students on a one to one basis may even increase the individual differences. Carroll argues that "two people who have been treated by different procedures will at least in some respect be different by virtue of the different procedures."[31] To substantiate his argument Carroll sites Gagne's proposal that signed numbers can be taught by verbal, spatial or symbolic methods. The dangers created by this type of instructional differentiation is pointed out as:

> A child who has been taught spatially will have a concept of signed numbers different from the concept attained by a child taught with a purely verbal procedure, and even though the children may have the same score on a performance test, the difference might show up in a dramatic form when the two children start to study some more advanced form of mathematics, say higher algebra. Then Cronbach's method 3b, rather then adapting to or reducing individual differences, may actually have the effect of accentuating or increasing individual differences.[32]

It seems, then, that trying to reduce individual differences by providing a unique instructional method for each learner may create a problem of its own. The solution to a problem may in turn become another problem.

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[31]Carroll, ibid., p. 43.

[32]Ibid.

An effort to erase individual differences by multivariate diagnostic testing and matching instructional methods to the learner is much more complex than one cares to realize. Professor Jensen suggests a classification of individual differences in terms of intrinsic and extrinsic individual differences. This is explained as:

> The essence of the difference is exemplefied by the two statements: (a) individual difference in learning, and (b) the effects of individual differences on learning.
>
> Extrinsic ID's are those subject variables which operationally bear no resemblance to the learning process ... Yet these ID's may influence the individual's performance in a learning situation ... By the term intrinsic individual differences which are inherent in learning and which do not exist independently of learning phenomena. In other words, intrinsic individual differences consist of intersubject variability in the learning process itself.[33]

The role of intrinsic individual differences in learning is supported by the research conducted by Newson, Eischens and Looft.[34] It is this difference among individuals which Cronbach hopes to match with instructional methods. The complexity and the impracticability of the

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[33] Arthur R. Jensen, "Varieties of Individual Differences in Learning" in <u>Learning and Individual Differences</u> by Robert M. Gagne, (ed.), (Charles E. Merrill Books Inc., Columbus, Ohio, 1967), p. 121.

[34] R.S. Newson, R. Eischens, and W.R. Looft, "Intrinsic Individual Differences: A Basis for Enhancing Instructional Programs," <u>The Journal of Educational Research</u>, (Vol. LXV, No.3 , May -- June, 1972), pp. 387-392.

situation can be ascertained by closely examining the number of variables in Jensen's taxonomic cube. Jensen explains his taxonomic cube model as:

> ... this domain of individual differences in learning can be facilitated if we hold in mind the following picture. Imagine a very large cube made of many small cubes ... This 3-dimensional figure can be used to represent three major classes of variables and the enclosed 3-dimensional space in which almost any particular learning task may be located ...[35]

Jensen's taxonomic cube represents types of learning on the horizontal axis, the procedures of learning on the vertical axis and the content and modality of learning on the perpendicular axis, going from front to back. See Figure 3, page 33. From this taxonomic cube one can determine the number of possible variables required for devising an instructional strategy for a task to be learned. Since every individual is different with respect to the intrinsic and extrinsic variables, the interaction between an individual and the task to be learned must also be specific for each individual. However, to find a specific instructional method for each and every learner to suit each and every task is quite cumbersome. The problem of finding an appropriate learning method is described by Professor Jensen as "I feel very much like one of the legendary blind men who tried to describe an elephant. At

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[35]Jensen, ibid., pp. 122-123.

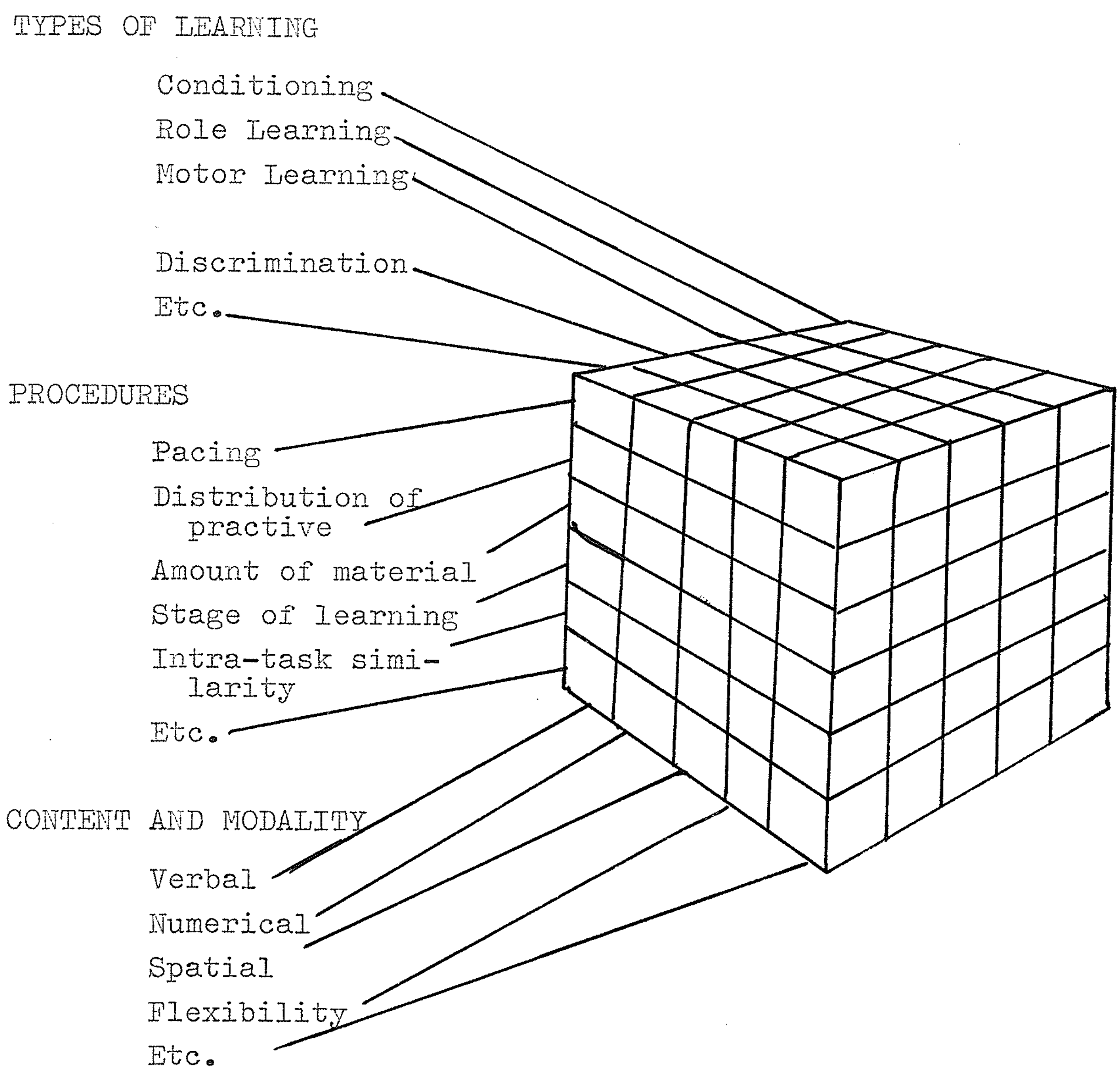

Figure 3

Jensen's Taxonomic Cube[36]

[36]Jensen, ibid., p. 123.

this stage more then one approach is obviously wanted."[37] The multivarious nature of human learning indicates that not one but many approaches will be required to accommodate individual differences.

At the instructional level the difference among the individuals is noticed by any thoughtful teacher. However, too often the practicing teacher makes very little effort to erase the individual differences. It is time the educators and society at large stopped paying lip service to the individual differences and start implementing some of the solutions. Helen Hefferman states that:

> Any thoughtful teacher will say that his greatest problem is in meeting the wide range of needs present in every classroom. ... If we believe individuals differ from one another in every conceivable way, let us really put this belief into action. Obviously, if individual variation exists then everyone will not be able to do the same things in the same amount of time and with equal degree of competence.[38]

The Mastery Learning Plan is but one effort towards the solution of this problem.

Self-Concept

The desire to erase individual difference is one of the pervasive factors responsible for the development of various types of individualized instructional programs.

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[37] Jensen, ibid., p. 134.

[38] Helen Hefferman, "Diverse Needs of the Individual Learner to be Served," (a paper presented at the National Conference on Rural Education, Oklahoma City, October 2, 1967), ERIC ED 014 340, p. 20.

There are factors such as self-concept, aptitude, self-learning, and motivation which played a significant role in the development of alternate instructional strategies. The lack of an adequate self-concept is responsible for the failure of many students. The continual unsuccessful learning experiences have left a deep scar in the minds of many students. Don E. Hamachek[39] states that low academic achievement may be related to a student's conception of himself as unable to learn academic material. Further, he suggests that a student's positive self-image can lead to a high academic achievement. Bloom's view on the subject of self-concept is very much similar to Hamachek. Bloom states that although the occasional unsuccessful learning experiences have a positive effect on further learning, on the contrary, repeated unsuccessful learning experiences may produce a deep sense of inadequacy. The ratio of successful learning experiences to unsuccessful learning experiences which will enhance the sense of adequacy to school learning is different for different individuals. According to Bloom, "successful experiences in school are no guarantee of a general positive self-concept, but they increase the probability that such will be the

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[39]Don E. Hamachek, "Motivation in Teaching and Learning," What Research Says to the Teacher, (Association of Classroom Teachers, Washington, D.C., No. 34, 1968), ERIC ED 029 845, p. 8.

case."[40] It seems that not every objective success or failure in external appraisal leads to a change in the self-concept, but the overall pattern of the result of such external objective appraisal that may lead to a positive or negative self image. It is basic human nature to strive for better self worth. If the school cannot help the student to develop a sense of adequacy then he will search for it elsewhere.

The effects of continual lack of external reinforcement through achievement tests on student's performance in learning has been studied by Seashore and Bavelas. The authors report that there is close correlation "between persistence at a task and some form of external reinforcement."[41] A study similar to the above was conducted by Sears[42] to determine the effect of academic success on the levels of aspirations. Sears came to the conclusion that experiences of success and failure have an influence on student's levels of aspiration. The failure group tended to show a lower level of aspiration as compared to

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[40] Benjamin S. Bloom, "Affective Consequences of School Achievement," in Mastery Learning by James H. Block, (Holt, Rinehart and Winston, Inc., Toronto, 1971), pp. 21-23.

[41] H.B. Seashore, and A. Bavelas, "A Study of Frustration in Children," Journal of Genetic Psychology, (Vol. LXI., 1942), p. 314.

[42] Pauline S. Sears, "Levels of Aspiration in Academically Successful and Unsuccessful Children," Journal of Abnormal Social Psychology, (Vol. XXXV., 1940), pp. 498-536.

the success group. Similarly, Feather,[43] through his research, arrived at a conclusion which showed that the student's general orientation toward a task is influenced by his initial success or failure. Also, the student's general expectations of success was influenced by his earlier learning experiences. Combs, and Spoer[44] also state that a positive view of oneself is gained from success and not from failure. This view is further substantiated by Brookover, Shailers and Paterson in their study conducted to show the effect of self concepts and school achievement. The major findings of this study are:

> First, the possibility that self concept may be changed should be noted. Second, if changes in self concept may lead to changes in academic performance, then, it is also possible that changes in self concept ... Finally, the study clearly shows that self concept derives from individual's perception of the evaluations ...[45]

From the study of Brookover et al it seems that successes in academic performance lead to a positive change in self-concept of the individual learner.

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[43]N.T. Feather, "Effect of Success and Failure on Expectations of Success and Subsequent Performance," Journal of Personality and Social Psychology, (Vol. III.), pp. 287-298.

[44]Arthur Combs and D.W. Spoer, "The Perceptual Organization of Effective Councellors," Journal of Counselling Psychology,(Vol. X, No. 3, Fall, 1963), pp. 222-226.

[45]Wilbur B. Brookover, Thomas Shailer, and Ann Paterson, "Self-Concept of Ability and School Achievement," Sociology of Education, (Vol. XXXVII), p. 278.

Rate of Learning

From the discussion of the role of academic achievement and self-concept it seems that one of the tasks of the educational system is to increase the learner's chances for success in learning. One method by which this can be achieved is by allowing a student to progress at his own rate. This method reduces the student's frustration caused by having to move ahead with other students. This view is supported by Glaser as:

> The possibilities of any one individual attaining competence is enhanced. Since the environment in which he can progress is adapted to his requirements and purposes, undiluted by the frustration of moving ahead with the brighter students or discouragement of just keeping up with the less bright students.[46]

Glaser suggests that by allowing a learner to progress without any hindrance from his fellow learner will enhance "attaining of Competence". Briefly, the Mastery Learning Plan will employ a technique by which the learner will be allowed to progress to a certain extent at his own rate.

Role of Teacher

In this type of learning situation the role of a teacher is to help the learner to learn. The role of the teacher is explained by Babcock as:

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[46]Robert Glaser, "The Education of Individuals," (Learning Research and Development Center, University of Pittsburg, September, 1966), ERIC ED 014 785, p. 2.

> It means the function of the teacher is to provide the minimum knowledge essential to triggering the thought processes. He provides, in effect, the generative structure upon which and within which the students work. In short his major role is helping students learn how to learn, and since learning is a personal experience, the teacher's role must be with each individual.[47]

Thus the teacher promotes learning by creating an environment which is conducive to learning.

The teacher is a diagnostician, a prescriber and an evaluator of students' learning. The formative ongoing evaluation provides a source of feedback both for the teacher and the learner. Airasian discusses the role of formative evaluation as:

> Basically; formative evaluation seeks to identify learning weaknesses prior to the completion of instruction on a course segment ... It should strive to identify unmastered learning areas early enough to permit their correction before the grading evaluation.[48]

The role of the teacher is to diagnose weaknesses in students' learning and prescribe appropriate corrective measures to overcome the learner's difficulty. Finally, the teacher must, through summative evaluation, provide the overall assessment of the student's learning.

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[47]Chester D. Babcock, "The Urgency of Individualized Instruction," (A paper presented at the Northwest Drive in Conference on Administrative Leadership, Spokane, Washington, November, 1967), ERIC ED 017 978, p. 2.

[48]Peter W. Airasian, "The Role of Evaluation in Mastery Learning," in Mastery Learning by James H. Block, (Holt, Rinehart and Winston, Inc., Toronto, 1971), p. 79.

In closing, this learning plan will be implemented in a self-contained normal classroom setting. The Mastery Learning Plan will attempt to accommodate individual differences in learning and enhance the self-concept of students.

Chapter 3

THE MASTERY LEARNING PLAN

DEFINITION OF TERMS

Before embarking on the delineation of the Mastery Learning Plan a brief note on the clarification of the term "Mastery" is in order. The term "mastery" according to Carroll,[49] is the achievement of an A level in a given course. But the exact meaning of an achievement of an A level is ambiguous. The ambiguity of the meaning of mastery can be overcome by closely scrutinizing the role of evaluation in the instructional process. An evaluation process can serve to sort out mechanical errors from conceptual errors. There are certain mechanical errors which can be overcome through prolonged practice; whereas, the conceptual errors if left untreated will hinder further learning. The teacher in his professional role as an evaluator will sort out mechanical errors from conceptual errors. Having sorted out the two types of errors, the teacher will then decide whether the student has grasped the basic root of the concept or not. If the student, in the opinion of the teacher, has demonstrated the attainment of all of the behavioral objectives

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[49] John B. Carroll, "Model of School Learning," Teacher College Record, (Vol. LXIV, 1963), pp. 723-733.

of the unit, then, he will be allowed to continue to the next unit. The term "Mastery Learning", according to this program, is defined as the learning which shows no conceptual errors on the unit test. In the final analysis the classification of the types of errors is left up to the individual teacher.

The term "continuing students" is used in reference to the number of Chemistry 200 students who have shown a desire to take the Chemistry 300 course.

The term "aptitude" is used in reference to the basic mathematical, language and manipulative skills, as measured by Otis Beta IQ test, necessary for the study of Chemistry 200.

The term "motivation" is used in reference to the students' favorable disposition toward the learning of Chemistry.

The term "summative test" will have the same meaning as the current final examination.

THE IMPLEMENTATION OF THE MASTERY LEARNING PLAN

The reader is reminded at this point that this plan can be implemented within the existing school program. The Mastery Learning Plan is based on the unit system. That is, the Chemistry 200 course will be divided into ten major topics. One unit for each major topic. Within the framework of a regular classroom setting the learner will be provided with the opportunity to work independently, at his own rate, in order to master the concepts of the unit at hand. The learner can seek help from his fellow students or from his teacher. The main requirement is that the learner must complete the overall Chemistry 200 program within the framework of a school year or semester, the student is required to complete the unit in the maximum number of class periods as prescribed in the unit outline. The assigning of maximum number of class periods per unit is derived from the past teaching experience. It is conceivable that a fast learner may complete the unit in half the allowed time where as the slow learner may require all or more time than prescribed for a given unit. If a learner requires more time on one unit then he must make up the loss of time on another unit. The amount of time required for learning is flexible as long as the overall Chemistry 200 program is completed within the framework of a school year or a semester. The fast learner, who finishes the program well before the allowed time, is given the opportunity to acquire bonus points on the final grade by doing a project in Chemistry. In this way the fast learner is allowed to pursue a topic of his interest. The slow learner, on the otherhand, is allowed to take units which require a special assistance.

At the beginning of the term Chemistry 200 course agenda is given to all students. The agenda consists of a list of units to be completed as well as tentative completion date for each unit. In this way student or parent is kept informed on whether one is ahead or behind the schedule. At the beginning of term students are made aware of the method of measurement and evaluation thereof. The measurement and assigning of letter grade is as follows:

Completing all the assignments	
1 point per unit x 10 units	10 points
Completing unit tests on first try without any conceptual error	
1 point per unit x 10 units	10 points
Completing unit tests on subsequent try	
½ point per unit x 10 units	5 points
Project	5 points
Final examination	15 points
Maximum possible	45 points

The following conversion scale is used to convert points to letter grades:

A	32 - 40 points
B	26 - 31 points
C	21 - 25 points
D	0 - 20 points

The central theme of this plan is learning for mastery. One must be ready to recognize when the student has attained the mastery of a concept. The recognition of the mastery learning requires constant ongoing evaluation of the learning. During the course of the unit the students will have ample opportunity to practise problem solving techniques. The problems are parallel to the behavioral objectives of the unit. After the grading of assignment problems the students will have the opportunity, during class time, to discuss his errors with the teacher and work out ways to overcome his errors. When the learner has eliminated most of his conceptual mistakes through assignments, then, he will be ready to write a self test. The self test, again, is derived from the behavioral objectives specified in the unit. After the self test the learner must decide whether to seek further remedial help or to write a unit test. The unit test is administered at the completion of the unit. The instructor will evaluate the test and discuss the nature of errors with the student and suggest an alternate learning plan if necessary for mastery of all of the behavioral objectives of the unit. When the learner has demonstrated the total lack of conceptual errors in the unit test then he will be advised to proceed to the next unit. Consult Figure 4 and 5. In this manner the formative testing program is both diagnostic and prescriptive. In addition to the frequent ongoing unit tests, there will be an overall summative test to evaluate the students' ability to determine whether the student has achieved the specified behavioral objectives of the Chemistry 200 program. The students' final grade in the Chemistry 200 course will be a composite grade derived from the overall summative test and achievement on the individual unit.

THE BASIC FORMAT OF UNIT

Title

The title of the unit is descriptive of the topic contained (Appendix A).

Purpose and/or Overview of Unit

There will be a brief motivational information section indicating to the student the practical application of the knowledge of the unit. At times, the overview indicates the importance of the study of the unit in terms of the conceptual need of the later units (Appendix A).

Behavioral Objectives

The behavioral objectives will be in the cognitive domain. Each behavioral objective will be based on the cognitive levels of learning (Appendix A).

Time Constraint

There is an indication as to the maximum number of class periods within which the learner should complete the unit.

Flow Chart and/or Unit Outline

This indicates to the student the sequential order in which concepts or terms are to be studied and also, the sequential order in which appropriate learning activities take place. This chart also contains the list of related reading materials.

Content

This section of the unit contains teacher prepared notes on the topic contained in the unit. The notes are based on the past teaching experiences. The notes contain factual information as well as the solutions to the sample problems worked out in detail. This section does not replace, but supplements, classroom instruction and/or text book materials and as such provides another source of information for the student (Appendix A).

Activity and/or Assignments

This section of the unit consists of three or four assignments. Each assignment will contain problems related to the concept. Within each assignment, problems are arranged in the sequential order from the simple to the complex task. Assignment problems are parallel to the behavioral objectives. In addition to the assignment problems there are teacher designed laboratory experiments and/or games wherever feasible to enhance the attainment of concepts.

Self-Test

This section contains a test based on the behavioral objective as stated earlier in the unit. The students can write the self-test at a time and place convenient to him. The student is also allowed the freedom to mark his own test. The student may discuss the result of the self-test with the teacher if he so desires.

Test

There are three different but parallel achievement tests based on the behavioral objectives of the unit. Each student is required to discuss the results of the test with the teacher. The student must show that he has attained mastery of all of the behavioral objectives of the unit.

During the course of the unit the student has the opportunity to work at his own rate within the limits as set by the teacher. This plan is flexible enough to be implemented in a completely individualized instructional program or in a traditional instructional program.

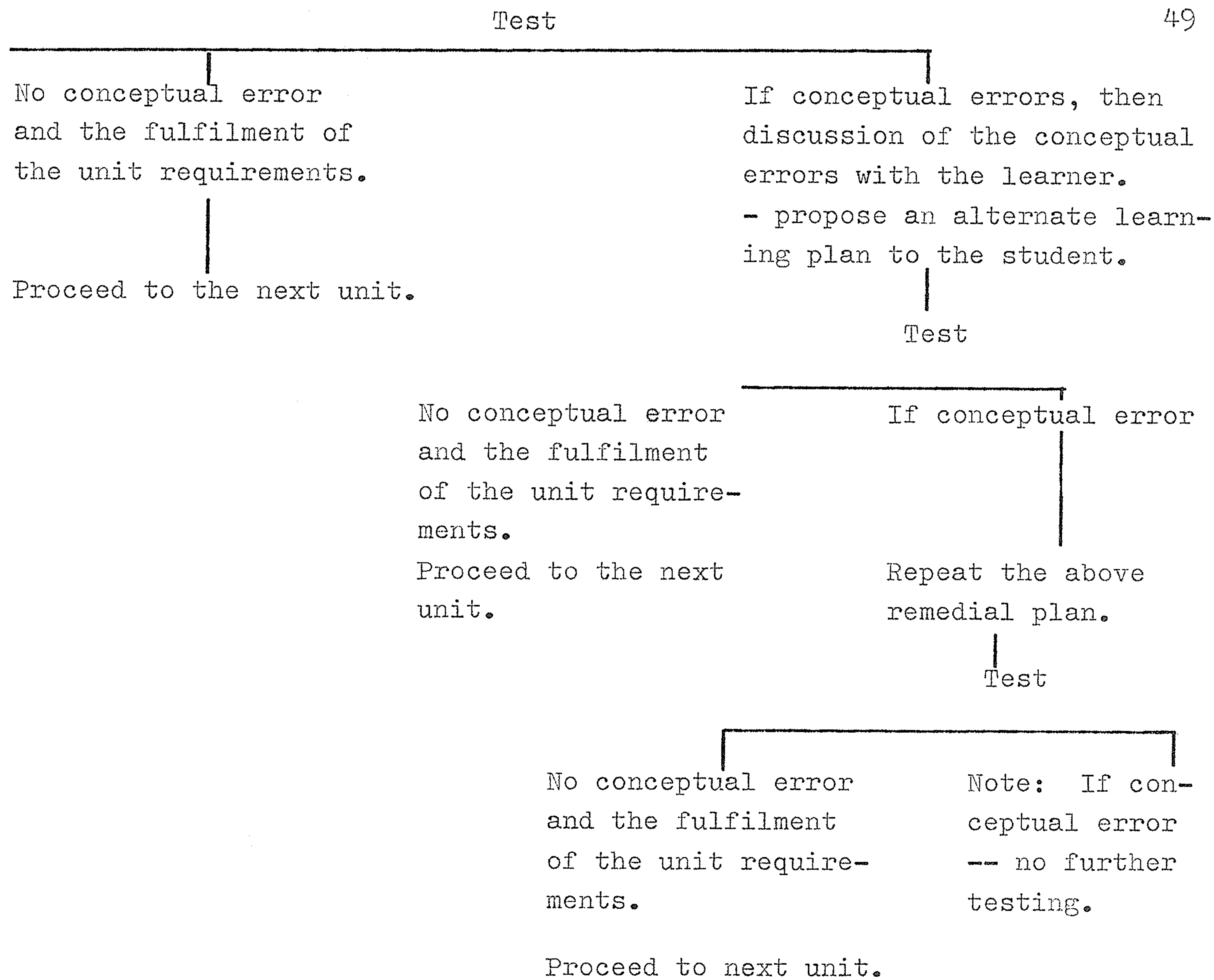

Figure 4

Format of Operational Strategy

1. SCIENTIFIC MODEL AND ATOMIC STRUCTURE.
2. MOLECULAR FORMULA AND MOLECULAR MASS.
3. MOLES -- MOLARITY.
4. CHEMICAL REACTIONS.
5. QUANTITATIVE RELAIONSHIPS IN CHEMICAL REACTIONS.

BUFFER ZONE -- PROJECT AND/OR REMEDIAL WORK
TO MEET SPECIAL NEEDS OF STUDENTS

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6. INTRODUCTION TO GASES.
7. MOLES -- GAS LAWS RELATIONSHIPS.
8. CHEMICAL CALCULATIONS.
9. THERMOCHEMISTRY.
10. RATES OF REACTION.

BUFFER ZONE -- PROJECT AND/OR REMEDIAL WORK TO
MEET SPECIAL NEEDS OF STUDENTS

SUMMATIVE TEST.

Figure 5

List of Units of Chemistry 200

Chapter 4

THE DESIGN OF THE EXPERIMENT

THE STUDY

The study was concerned with Grade 11 Chemistry commonly designated as Chemistry 200. The study began in September, 1973 and was completed in June, 1974. This investigation was concerned primarily with achievement in Chemistry and the attitude towards the learning of Chemistry.

Specifically the research involved the comparison between two different methods of instruction, namely the traditional learning procedure and a Mastery Learning Plan. There were two groups of students involved in this study. One group of students called the control group received instruction based on the traditional learning procedure while the other group of students, called the experimental group, received instruction based on a Mastery Learning Plan. Both groups of students were exposed to the same overall content of the Chemistry 200 program. Also, both groups of students received one hundred and ten hours of instruction as prescribed by the Curriculum Branch of the Department of Education of Manitoba. In addition the two groups of students were permitted to use the authorized texts Chemistry: An Experimental Science and Chemistry: An Experimental Science Laboratory Manual. The experimental group of students was allowed to use various books as prescribed in the unit flow chart.

Each group of students received a pre and post test consisting of an attitude test and an achievement test. During the course of this research, data was collected on each student's IQ and age from the school's cummulative file. The author taught both groups of students and made every effort to show the same degree of enthusiasm, patience and enterprise as he displayed in his other teaching.

POPULATION

The population consisted of all students enrolled in the Chemistry 200 program in the Westdale Junior-Senior High School in Winnipeg, Manitoba in the 1973-74 school year. Altogether there was a total of thirty-nine students enrolled in the Chemistry 200 course. The control group consisting of twenty-one students was taught in the first semester and the experimental group of sixteen students was taught in the second semester of the 1973-74 school year. The students came from a middle class suburban area of Winnipeg, Manitoba.

ATTITUDE MEASUREMENT

The attitude test administered to all Chemistry 200 students at the beginning and end of the Chemistry course was designed to determine the attitude of students towards the learning of Chemistry. The test consisted of twenty-five items; each item being a statement intended to measure the students attitude towards the learning of Chemistry. Thirteen items were of a positive nature, such as, "Chemistry is very interesting to me and I enjoy Chemistry". Twelve items were of a negative nature such as, "I do not like Chemistry and it scares me to have to take Chemistry". The students' response to each item was measured by using a "Likert Scale of Marking" (Table 1). The students were instructed to indicate their choice by circling the appropriate answer. The following choices were given.

SD - strongly disagree
D - disagree
N - neither agree nor disagree
A - agree
SA - strongly agree

The overall arithmetic sum of all the points earned on the test was considered to be representative of the students' attitude towards the learning of Chemistry.

The instructions given with the attitude tests were designed to ensure an honest response from the students.

The attitude test instrument used in the study was a modified version of a mathematics Attitude Scale

Table 1

Points Assigned to Items on Attitude Test

Response	Type of Statement	Points
SD	positive	1
D	positive	2
N	positive	3
A	positive	4
SA	positive	5
SD	negative	5
D	negative	4
N	negative	3
A	negative	2
SA	negative	1

developed by Marvin E. Shaw and Jack M. Wright,[50] the University of North Carolina. The original instrument contained twenty items whereas, the modified version contained twenty-five items (Appendix B). The five additional items were added to the original twenty items to suit the needs of this particular study. Under the marking scale the maximum score possible was 125 (25 items times 5 points maximum) while the minimum score possible was 25 (25 items times 1 point minimum).

ACHIEVEMENT MEASUREMENT

The achievement test contained two parts, one part containing fifty multiple choice items with four possible choices per test item; part two contained stoichiometric problems. The students were required to show all the major steps in the solution of the problem. In the scoring of the second part the students received part marks for each correct step. The multiple choice items were marked on a right or wrong basis. The maximum score possible for part one was one hundred points (two points per items) while the maximum score for part two was thirty points bringing the total possible score to one hundred and thirty points. A maximum time of two hours was allowed for completion of the achievement test

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[50]Marvin E. Shaw, and Jack M. Wright, Scales for the Measurement of Attitudes, (New York: McGraw Hill Book Company, 1967), pp. 15-16.

(Appendix D).

The achievement test, administered to both the control and the experimental group on the first and last teaching days of the Chemistry 200 course, was designed to measure the cognitive area of the course. Comparisons of test items with concepts revealed that the test items adequately covered the content of Chemistry 200 course.

STATISTICAL DESIGN AND THE LEVEL OF SIGNIFICANCE

In order to determine whether there was any significant difference in student's achievement and attitude towards the learning of Chemistry the independent t-test was employed. A level of significance of .01 on two tailed independent t-test was employed to investigate fourteen null hypotheses. The independent t-values were computed where,

$\bar{X}$ = mean of the experimental group

$\bar{Y}$ = mean of the control group

n_1 = 16

n_2 = 23

S_1 = standard deviation of the experimental group

S_2 = standard deviation of the control group

The statistical design of the overall study was as follows:

The Control Group	Vs	The Experimental Group
pre-achievement test	$\xleftrightarrow{Ho_1}$	pre-achievement test
pre-attitude test	$\xleftrightarrow{Ho_2}$	pre-attitude test
chronological age	$\xleftrightarrow{Ho_3}$	chronological age
IQ	$\xleftrightarrow{Ho_4}$	IQ
post-achievement test	$\xleftrightarrow{Ho_5}$	post-achievement test
post-attitude test	$\xleftrightarrow{Ho_6}$	post-attitude test

The Experimental Group

High IQ pre-achievement test	$\xleftrightarrow{Ho_7}$	High IQ post-achievement test
Low IQ pre-achievement test	$\xleftrightarrow{Ho_8}$	Low IQ post-achievement test
High IQ pre-attitude test	$\xleftrightarrow{Ho_9}$	High IQ post-attitude test
Low IQ pre-attitude test	$\xleftrightarrow{Ho_{10}}$	Low IQ post-attitude test

The Control Group

High IQ pre-achievement test	$\xleftrightarrow{Ho_{11}}$	High IQ post-achievement test
Low IQ pre-achievement test	$\xleftrightarrow{Ho_{12}}$	Low IQ post-achievement test
High IQ pre-attitude test	$\xleftrightarrow{Ho_{13}}$	High IQ post-attitude test
Low IQ pre-attitude test	$\xleftrightarrow{Ho_{14}}$	Low IQ post-attitude test

The first four null hypotheses were tested to determine if there were any significant differences at the .01 level. The author hoped to accept the first four null hypotheses and reject the alternate hypothesis. By accepting the first four null hypotheses one would establish the statistical equivalency between the control and the experimental group.

Chapter 5

ANALYSIS OF THE DATA

The data accumulated during the course of this research were organized into a table (Appendix E). The statistical treatment of the data involved the following steps:

(1) The mean $\bar{X}$ of each sample, was calculated by dividing the algebraic sum of (X) of each score $\bar{X}$ in the sample by the number of elements, n in the sample.

(2) The difference between each score, X in the sample, and the mean, $\bar{X}$ of the sample was determined. For example, for a student whose score is 21 and the mean of the sample is 19, the difference is $(X-\bar{X}) = 21-19 = 2$.

(3) The squares of the difference $(X-\bar{X})$ were determined as $(X-\bar{X})^2 = (21-19)^2 = (2)^2 = 4$.

(4) The sum for the squares of the difference $(X-\bar{X})^2$ was determined.

(5) The standard deviation, S for a set of scores was determined as follows:

$$S = \sqrt{\frac{\sum(X-\bar{X})^2}{n-1}}$$

Where X = scores

$\bar{X}$ = mean of scores of the sample

n = number of elements in the sample

S = standard deviation

(6) The independent t-value for two sets of scores was computed as:

$$t = \frac{\overline{X}-\overline{Y}}{\sqrt{\frac{(n_1-1)S_1^2 + (n_2-1)S_2^2}{} \left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

where $\overline{X}$ = mean of the sample one

$\overline{Y}$ = mean of the sample two

S_1 = standard deviation of the sample one

S_2 = standard deviation of the sample

n_1 = number of elements in the sample one

n_2 = number of elements in sample two

(7) The degrees of freedom, df was determined by taking the sum of elements in two samples being compared and then subtracting two from the sum, i.e., if $n_1 = 23$ and $n_2 = 1$ then df $= 23 + 16-2 = 37$.

(8) The degrees of freedom, df was used to determine the t values for a two tailed test. The level of significance, was .01 on two tailed t-test.

(9) The t-value obtained in step 8 was used to establish the zones of acceptance and rejection of null hypothesis. Since it was possible for the mean of the post-test scores to be either greater or less than the mean of the pre-test scores there were two possible critical t-values. One, where the critical t-value was positive and the other where critical t-value was negative.

(10) The t-test had a two sided alternative because it was possible for the post-test results to be either higher or lower than the pre-test results. To test at a level of significance, of 0.01, $t_{.005}$ was used in the establishment of the zones of acceptance or rejection of null hypothesis. One half of one per cent area under the graph fell on either extremities. Consider Figure 6 for a detailed explanation.

FIRST HYPOTHESIS

The first hypothesis investigated the difference in the mean of the pre and post achievement test scores of the control and the experimental group. If the difference in the mean of the pre-test scores of the two groups was equal to or near zero then two groups could be statistically equal with respect to the initial knowledge. Also, if the standard deviations of the pre-test scores of the two groups were of equal spread in terms of student's pre-knowledge of chemistry. Table 2 gives the statistical analysis of the pre-achievement test scores.

SECOND HYPOTHESIS

The second hypothesis was designed to compare the similarity of the two groups in terms of their initial attitude towards the learning of chemistry. The statistical analysis of the pre-attitude test scores of the control and the experimental group is given in Table 3.

THIRD HYPOTHESIS

The third hypothesis was designed to investigate the basic aptitude of the two groups involved in study. Aptitude, as a measure of basic ability, was inferred from Otis Beta Intelligent Quotient scores. The IQ scores for each participant was obtained from the Westdale High School's cummulative file. An assumption is made that IQ scores remained constant during the course of this study. The mean as well as the standard deviation of the two group's IQ scores would provide information regarding the initial similarity of the two groups in terms of the basic aptitude. Consider Table 4 for the statistical analysis of the IQ scores.

FOURTH HYPOTHESIS

The fourth hypothesis investigated the similarity in the mean age of the control and the experimental group. The data regarding the ages was collected from the school file. Students' age was determined as of the first day of their Chemistry class. Then student's age was rounded off to the nearest half year. That is, sixteen years and seven months was rounded off to 16.5 years. Table 5 gives the statistical analysis of the ages of the two groups.

FIFTH HYPOTHESIS

The first four hypotheses sought the initial similarity between the control and the experimental group. Whereas, the fifth and the sixth hypotheses attempted to investigate the difference in the mean of post scores. Specifically, the fifth hypothesis investigated the difference in the mean of the post-achievement scores of the control and the experimental group. Consider Table 6 for the statistical analysis of the post-achievement scores.

SIXTH HYPOTHESIS

The sixth hypothesis compared the mean of the post-attitude scores of the control and the experimental group. If the mean of the post-attitude score of the experimental group was less than the mean of the post-attitude score of the control group, then, the t-value will have a positive value. The negative value of the t-test would indicate that the mean of the post-attitude score of the experimental group was greater than the mean of the post-attitude score of the control group. Consider Table 7 for the statistical analysis of the post-attitude scores of the two groups.

SEVENTH AND EIGHTH HYPOTHESES

The seventh and eighth hypotheses attempted to determine the effect on student achievement, if any, of the Mastery Learning Plan on the high IQ and low IQ students of the experimental group. Specifically, the seventh hypothesis tested the significant difference in the means of the pre and post achievement test scores of the high IQ students who experienced the Mastery Learning Plan. Similarly, the eighth hypothesis tested the significant difference in the means of the pre and post attitude test scores of the low IQ students who were exposed to the Mastery Learning Plan. Students with an IQ equal to or less than 110 were classified as low IQ students whereas students with an IQ greater than 110 were classified as high IQ students. The accumulated data was statistically treated to determine the t-value. Consider Table 8 for the statistical analysis of the data.

NINTH AND TENTH HYPOTHESES

The ninth and tenth hypotheses investigated the effect on student's attitude, if any, of the Mastery Learning Plan on high IQ and low IQ students of the experimental group. The ninth hypothesis attempted to investigate the significant difference, if any, in the means of the pre and post attitude test scores of high IQ students who were exposed to the Mastery Learning Plan. Similarly, the tenth hypothesis tested the significant difference, if any, in the means of the pre and post attitude test scores of the low IQ students who experienced the Mastery Learning Plan. Consider Table 9 for the statistical analysis of the accumulated data.

ELEVENTH AND TWELFTH HYPOTHESES TESTED

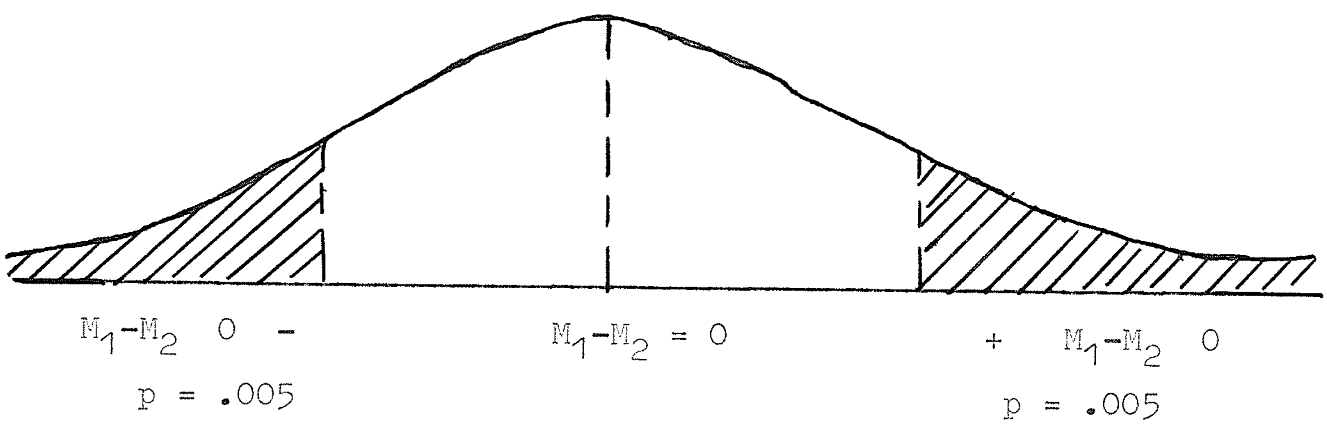
The eleventh and twelfth hypotheses tested the effect on student achievement, if any, of the traditional learning procedure on high IQ and low IQ students of the control group. Specifically, the eleventh hypothesis tested the significant difference in mean scores of achievement, as measured by pre and post test, of high IQ students of the control group. Similarly, the twelfth hypothesis determined the significant difference in the means of pre and post achievement test scores of low IQ students of the control group. Consider Table 10 for the statistical analysis of the data.

THIRTEENTH AND FOURTEENTH HYPOTHESES

The thirteenth and fourteenth hypotheses tested the effect on student's attitude, if any, of the traditional learning procedure on high IQ and low IQ students of the control group. The thirteenth hypothesis determined the significant difference in the means of pre and post attitude test scores of high IQ students of the control group whereas the fourteenth hypothesis tested the significant difference in the means of pre and post attitude test scores of low IQ students of the control group. Consider Table 11 for the analysis of the data.

SUMMARY

The statistical analysis of the data revealed information about the two group's attitudes and achievement. Further, the analysis of the data provided experimental evidences necessary for answering questions stated in the Chapter 1 of the study. On the basis of the derived t-values decisions can be made regarding the acceptance or rejection of various null or alternate hypotheses.



Key:

☐ Zone of acceptance of null hypothesis if t-experimental fell in this area

▨ Zone of rejection of null hypothesis if t-experimental fell in this area

Figure 6

A Hypothetical t-Distribution

Table 2

Values of Mean ($\bar{X}$), Standard Deviation (S), Degrees of Freedom (df), t-Experimental, and $_{.005}t_{37}$ of Pre-Achievement Test Scores of the Two Groups

	The Control Group	The Experimental Group
The mean $\bar{X}$	28.4348	28.000
Standard deviation, S	6.874	6.851
df	23 + 16-2 = 37	
t-experimental	+ .19	
Critical values of $_{.005}t_{37}$	$\pm$2.704	

Table 3

Values of Mean ($\bar{X}$), Standard Deviation (S), Degrees of Freedom (df), t.Experimental and $_{.005}t_{37}$ of Pre-Attitude Test Scores of the Two Groups

	The Control Group	The Experimental Group
The mean $\bar{X}$	88.00	90.6250
Standard deviation, S	11.217	13.544
Degree of Freedom, df	23 + 16-2 = 37	
t-experimental	-.66	
Critical values of $_{.005}t_{37}$	$\pm$2.704	

Table 4

Values of Mean ($\overline{X}$), Standard Deviations (S), Degrees of Freedom (df), t-Experimental and ${}_{.005}t_{37}$ of IQ Scores of the Two Groups

	The Control Group	The Experimental Group
Mean, ($\overline{X}$)	115.9130	112.8125
Standard deviations, (S)	11.485	9.268
Degrees of freedom (df)	23 + 16-2 = 37	
t-experimental	+.89	
Critical values of ${}_{.005}t_{37}$	+2.704	

Table 5

Values of Mean ($\overline{X}$), Standard Deviation (S), Degrees of Freedom (df), t-Experimental and ${}_{.005}t_{37}$ for the Chronological Ages of the Two Groups

	The Control Group	The Experimental Group
Mean, ($\overline{X}$)	16.304	16.844
Standard deviations, (S)	.703	1.076
Degrees of freedom (df)	23 + 16-2 = 37	
t-experimental	-1.897	
Critical values of ${}_{.005}t_{37}$	$\pm$2.704	

Table 6

Values of Mean ($\bar{X}$), Standard Deviations (S), Degrees of Freedom (df), t-Experimental and $_{.005}t_{37}$ of Post-Achievement Scores of the Two Groups

	The Control Group	The Experimental Group
Mean, ($\bar{X}$)	48.2609	63.9375
Standard deviation (S)	18.410	16.085
Degrees of freedom (df)	23+16-2 = 37	
t-experimental	-2.75	
Critical values of $_{.005}t_{37}$	± 2.704	

Table 7

Values of Mean ($\bar{X}$), Standard Deviations (S), Degrees of Freedom (df), t-Experimental and $_{.005}t_{37}$ of Post-Attitude Test Scores of the Two Groups

	The Control Group	The Experimental Group
Mean, ($\bar{X}$)	83.6087	96.8125
Standard deviations (s)	14.773	10.134
Degrees of freedom (df)	23 + 16-2 = 37	
t-experimental	-3.10	
Critical values of $_{.005}t_{37}$	± 2.704	

Table 8

Values of Mean ($\bar{X}$), Standard Deviation (S), Degrees of Freedom (df), t-Experimental, and ${}_{.005}t_7$ of Pre and Post Achievement Test Scores of High and Low IQ Students of the Experimental Group

	HIGH IQ		LOW IQ	
	Pre-achievement test scores	Post-achievement test scores	Pre-achievement test scores	Post-achievement test scores
Mean, ($\bar{X}$)	28.500	75.1250	27.7500	52.7500
Standard deviations (S)	4.334	11.256	9.036	11.901
Degrees of freedom (df)	7		7	
t-experimental	-11.21		-9.81	
Critical values of ${}_{.005}t$	±3.499		±3.499	

Table 9

Values of Mean ($\bar{X}$), Standard Deviations (S), Degrees of Freedom (df), t-Experimental and ${}_{.005}t_7$ of Pre and Post Attitude Test Scores of High and Low IQ Students of the Experimental Group

	HIGH IQ		LOW IQ	
	Pre-attitude test scores	Post-attitude test scores	Pre-attitude test scores	Post-attitude test scores
Mean, (X)	89.6250	98.7500	91.6250	94.8750
Standard deviations (S)	10.914	6.585	16.483	12.966
Degrees of freedom (df)	7		7	
t-experimental	-4.94		-1.08	
Critical values of ${}_{.005}t$	±3.499		±3.499	

Table 10

Values of Mean ($\overline{X}$), Standard Deviations (S), Degrees of Freedom (df), t-Experimental, and $_{.005}t$ of Pre and Post Achievement Test Scores of High and Low IQ Students of the Control Group

	HIGH IQ		LOW IQ	
	Pre-attitude test scores	Post-attitude test scores	Pre-attitude test scores	Post-attitude test scores
Mean, ($\overline{X}$)	31.4286	57.8571	23.7778	33.3333
Standard deviations (S)	6.047	15.786	5.518	10.735
Degrees of freedom (df)	13		8	
t-experimental	-7.17		-2.23	
Critical values of $_{.005}t$	$\pm$3.012		$\pm$3.355	

Table 11

Values of Mean ($\overline{X}$), Standard Deviation (S), Degrees of Freedom (df), t-Experimental, and $_{.005}t$ of Pre and Post Attitude Test Scores of High and Low IQ Students of the Control Group

	HIGH IQ		LOW IQ	
	Pre-achievement test scores	Post-achievement test scores	Pre-achievement test scores	Post-achievement test scores
Mean, ($\overline{X}$)	90.2857	87.2857	84.4444	77.8889
Standard deviations (S)	12.554	14.704	8.156	13.724
Degrees of freedom (df)	13		8	
t-experimental	+.98		+1.69	
Critical values of $_{.005}t$	$\pm$3.012		$\pm$3.355	

Chapter 6

SUMMARY, INTERPRETATION OF DATA AND CONCLUSIONS

SUMMARY

Thrity-nine Grade 11 students enrolled in the Chemistry 200 course and were involved as subjects in the research. Of the thirty-nine students, twenty-three were classified as the control group while the remaining sixteen were classified as the experimental group. The control group was exposed to the traditional learning procedure while the experimental group was taught according to the Mastery Learning Plan. Each group received pre and post attitude and achievement tests. The scores of these tests were statistically analyzed in order to determine the effect of the Mastery Learning Plan on students' attitude and achievement.

In order to provide a general direction to the study six questions were developed. The development of null hypotheses provided the specific direction for the study. Each null hypothesis was tested using an independent t-test. Consult Table 12 for the summary of the results of the statistical analysis of the accumulated data.

In addition to the objective evaluation of the data there were certain subjective observations made during the study. They are as follows:

(1) Relatively little, if any, class time was tested because students set their own priorities.

(2) Students displayed greater self-discipline and accepted the responsibility for completing course requirements.

(3) Students' needs were more easily determined and consequently students had better chance for success in this course.

(4) Failure on a unit test in a traditional sense was eliminated because students were given opportunity to relearn the necessary concept(s) and correct conceptual errors.

(5) Students progress to the next unit once they had mastered the previous unit.

(6) Students were allowed to progress at their own rate as long as the overall course was completed within the semester.

INTERPRETATION OF DATA

The first four null hypotheses attempted to determine the initial similarities of the students in the control and in the experimental groups with respect to student's achievement, attittude, age and IQ. All the experimentally determined t-values corresponding to the first four null hypotheses fall in the zone acceptance of null

Table 12

Summary of the Results of Statistical Analysis of Data

Null Hypotheses	t-Experimental	Critical Values $_{.005}t$	Action Re: Null Hypotheses	Inference
H_{O_1}	+.19	±2.704	accepted	Two groups were equal with respect to the initial knowledge of Chemistry.
H_{1_1}			rejected	
H_{O_2}	-.66	±2.704	accepted	Two groups had equal disposition toward the learning of Chemistry.
H_{1_2}			rejected	
H_{O_3}	+.89	±2.704	accepted	Two groups were of statistically equal chronological age.
H_{1_3}			rejected	
H_{O_4}	-1.897	±2.704	accepted	Two groups had statistically equal basic ability as measured by the Otis Beta IQ scores.
H_{1_4}			rejected	
H_{O_5}	-2.75	±2.704	rejected	Two groups were different with respect to their initial knowledge of chemistry.
H_{1_5}			accepted	
H_{O_6}	-3.10	±2.704	rejected	Two groups were different with respect to their initial attitude towards the learning of chemistry.
H_{1_6}			accepted	
H_{O_7}	-11.21	±3.499	rejected	There was a difference in the pre and post achievement test scores of high IQ students of the experimental group.
H_{1_7}			accepted	

Table 12 (continued)

Null Hypotheses	t-Experimental	Critical Values $_{.005}t$	Action Re: Null Hypotheses	Inference
H_{0_8}	-9.81	±3.499	rejected	There was a difference in the pre and post achievement test scores of low IQ students of the experimental group.
H_{1_8}			accepted	
H_{0_9}	-4.94	±3.499	rejected	There was a difference in pre and post attitude test scores of high IQ students of the experimental group.
H_{1_9}			accepted	
$H_{0_{10}}$	-1.08	±3.499	accepted	There was no difference in pre and post attitude test scores of low IQ students of the experimental group.
$H_{1_{10}}$			rejected	
$H_{0_{11}}$	-7.17	±3.012	rejected	There was a difference in the pre and post achievement test scores of high IQ students of the control group.
$H_{1_{11}}$			accepted	
$H_{0_{12}}$	-2.23	±3.355	accepted	There was a difference in the pre and post achievement scores of low IQ students of the control group.
$H_{1_{12}}$			rejected	
$H_{0_{13}}$	+.98	±3.012	accepted	There was no difference in the pre and post attitude test scores of high IQ students of the control group.
$H_{1_{13}}$			rejected	
$H_{0_{14}}$	+1.69	±3.355	accepted	There was no difference in the pre and post attitude test scores of the low IQ students of the control group.
$H_{1_{14}}$			rejected	

hypotheses. Consult Tables 2, 3, 4, and 5. On this basis one can accept the first four null hypotheses and can state that there were no significant difference in achievement, attitude, age and IQ between students in the control and the experimental group.

Hypothesis five stated that there would be no statistically significant difference in mean scores of post achievement tests between the experimental and the control group. Table 6 gives the t-value of -2.75. The t-value of -2.75 is less than the critical value of -2.704 and therefore falls in the zone of rejection of null hypothesis. This means that one must accept the alternate hypothesis, H_{1_5} and conclude that there was a significant difference in achievement between the experimental and the control group. That is, the student who followed the Mastery Learning Plan scored considerably higher on the post-achievement test than the student who experienced the traditional learning procedure.

Question one asked: Is there a significant difference in achievement in Chemistry between the student who experiences a Mastery Learning Plan and the student who follows the traditional learning procedure? Table 8 shows that there was significant difference in post-achievement test administered to the two groups. The student who was involved in the Mastery Learning Plan scored considerably higher than the student who followed the traditional learning procedure.

Hypothesis six stated that there would be no statistically significant difference in mean scores of post attitude test towards the learning of Chemistry between the experimental and the control group. Table 7 gives the t-value of -3.10. The t-value of -3.10 is less than the critical t-value of -2.0704, and therefore, falls in the zone of rejection of null hypothesis. This means that one must accept the alternate hypothesis, H_{1_7} and can state that there was a significant difference in student's attitude towards the learning of Chemistry between the experimental and the control group.

Question two asked: Is there a significant difference in student's attitude towards the learning of Chemistry between the student who experienced the Mastery Learning Plan and the student who followed the traditional learning procedure? Table 7 shows that the mean scores of the post attitude tests administered to the two groups. The student who followed the Mastery Learning Plan scored considerably higher than the student who followed the traditional learning procedure.

Hypothesis seven stated that there would be no statistically significant difference in mean scores of achievement, as measured by pre and post test, of high IQ students of the experimental group. Table 8 gives the t-value of -11.21. This t-value of -11.21 is less than the critical t-value of -3.499 and therefore falls in the zone of rejection of null hypothesis. This means that the alternate hypothesis, H_{1_7}, must be accepted and one can state that there was a significant difference in achievement between the pre and post test scores of the experimental group.

Hypothesis eight stated that there would be no difference in student achievement, as measured by the pre and post test, of the low IQ students of the experimental group. Table 8 gives the t-value of -9.81. The t-value of -9.81 is less than the critical t-value of -3.499, and therefore, falls in the zone of rejection of null hypothesis. On the basis of this result one must accept the alternate hypothesis, H_{1_8} and can state that there was a significant difference in the pre and post achievement test scores of the low IQ students of the experimental group.

Question three asked: Is there a significant difference in achievement between high IQ and low IQ students who experience the Mastery Learning Plan? Table 8 giving the t-values of -9.81 and -11.21 for low and high IQ students respectively, shows that there was a significant difference in achievement for both the high IQ and low IQ students of the experimental group. Thus, both high IQ and low IQ students benefited significantly from the Mastery Learning Plan.

Hypothesis nine stated that there would be no statistically significant difference in mean scores of pre and post attitude tests administered to high IQ students of the experimental group. Table 9 gives the t-value

-4.94. The t-value of -4.94 is less than the critical t-value of -3.499, and therefore, falls in the zone of rejection of null hypothesis. On this basis one must accept the alternate hypothesis, H_{1_9} and can state that there was a significant difference in pre and post attitude test scores of high IQ students of the experimental group.

Hypothesis ten stated that there would be no significant difference in mean scores of pre and post attitude tests administered to low IQ students of the experimental group. Table 9 gives the t-value of -1.08. The t-value of -1.08 is greater than the critical t-value of -3.499, and therefore, falls in the zone of acceptance of null hypothesis. This means that one must reject alternate hypothesis $H_{1_{10}}$ and can state that there was no significant difference in pre and post attitude test scores of low IQ students of the experimental group. In other words, the low IQ students of the experimental group attitude towards the learning of chemistry remained relatively unchanged.

Question four asked: Is there a significant difference in attitude towards the learning of chemistry between high IQ and low IQ students who experienced the Mastery Learning Plan? Table 9, giving the t-values of -4.94 and -1.08 for high IQ and low IQ students respectively, shows that there was a significant difference in pre and post attitude test scores for high IQ but not for low IQ students of the Mastery Learning Plan. Thus, according to Table 9 the high IQ students made a significant gain in their attitude towards the learning of chemistry, whereas the low IQ students did not make a significant gain in their disposition towards the learning of chemistry.

Hypothesis eleven stated that there would be no statistically significant difference in mean scores of pre and post achievement tests administered to high IQ students of the control group. Table 10 gives the t-value of -7.17. The t-value of -7.17 is considerably less than the critical t-value of -3.012, and therefore, falls in the zone of rejection of null hypothesis. On this basis one must accept the alternate hypothesis, $H_{1_{11}}$ and can state that there was a significant difference in pre and post achievement test scores of high IQ students of the control group.

Hypothesis twelve stated that there would be significant difference in mean scores of pre and post achievement tests administered to the low IQ students of the control group. Table 10 gives the t-value of -2.23 which is considerably greater than the critical t-value of -3.355 and therefore, falls in the zone of acceptance of null hypothesis. On this basis one can state that there was a significant difference in pre and post achievement test scores of low IQ students of the control group.

Question five asked: Is there a significant difference in achievement between high IQ and low IQ students who followed the traditional learning procedure? Table 10, giving the t-values of -7.17 and -2.23 for high and low IQ students respectively, shows that there was a significant difference in pre and post achievement test scores for high IQ but not for low IQ students of the control group. Thus, the traditional learning procedure provided a significant benefit, in the area of achievement, for high IQ students but not for low IQ students.

Hypothesis thirteen stated that there would be no statistically significant difference in mean scores of pre and post attitude tests administered to high IQ students of the control group. Table 11 gives the t-value of +.98. The t-value of +.98 is considerably less than the critical t-value of +3.012 and therefore, falls in the zone of acceptance of null hypothesis. On this basis one must reject the alternate hypothesis, $H_{1_{13}}$ and can state that there was a significant difference in pre and post attitude test scores of low IQ students of the control group.

Hypothesis fourteen stated there would be no statistically significant difference in mean scores of pre and post attitude tests administered to low IQ students of the control group. Table 11 gives the t-value of +1.69. The t-value of +1.69 is considerably less than the critical t-value of +3.355 and therefore, falls in the zone of acceptance of null hypothesis. On this basis one must reject the alternate hypothesis, $H_{1_{14}}$ and can state that there was no significant difference in pre and post attitude test scores of low IQ students of the control group.

Question six asked: is there a significant difference in attitude towards the learning of chemistry between high IQ and low IQ students of the control group? Table 11 giving the t-value of +.98 and +1.69 for high IQ and low IQ students shows that there was no significant difference in pre and post attitude test scores for high IQ and low IQ students of the control group. Thus, according to Table 11 both high IQ and low IQ students did not benefit significantly in terms of attitude towards the learning of chemistry from the traditional learning procedure.

CONCLUSION

Conclusion

The experimental evidence obtained through this study suggests that the Mastery Learning Plan enhanced student's achievement in Chemistry and attitude towards the learning of chemistry. Specifically, the student who followed the Mastery Learning Plan showed a significant gain in achievement. The student who followed the traditional learning procedure however, did not show a significant gain in achievement. Further analysis of the data revealed that both the high and low IQ students showed a significant gain in pre and post achievement test scores. On the basis of these findings it can be concluded that the Mastery Learning Plan was beneficial (with respect to achievement) to all the students involved in this study. However, with regards to attitude the high IQ student showed a significant gain while the low IQ student did not show any significant improvement. The low IQ student of the experimental group did show a gain in pre and post attitude test score but it was not a significant gain. On the whole it can be concluded that the Mastery Learning Plan was beneficial to all students of the experimental group.

Pre-tests showed that the experimental group and the control groups were similar in terms of ability, however, the post tests showed that the two groups differed significantly in attitude and ability. One could deduce that this difference was most likely caused by the difference in the teaching method, since the experimental group scored significantly higher than the control group, in achievement and attitude, that it would seem reasonable to conclude that this difference was brought about by the application of the Mastery Learning Plan.

The rationale for this study indicated that the student drop out and the decreasing enrollment in senior chemistry courses were some of the reasons for embarking on this study. In the control group there was eleven per cent of the students who discontinued their study of chemistry in the middle of the semester; whereas zero per cent of students in the experimental group discontinued their study of chemistry. In the control group only fifty-seven per cent of students registered for the Chemistry 300 course; whereas, one hundred per cent of students in the experimental group registered for the Chemistry 300 course. Thus it can be concluded that the Mastery Learning Plan appeared to reduce the drop out of students and increased the desire to continue further learning in chemistry.

Implications for Education

According to the results of the study, it appeared that the Mastery Learning Plan met the needs of students, allowed for the expression of individual differences and encouraged student motivation to a greater degree than that which would occur in the traditional learning procedure. These findings indicated the need for a structured learning environment. The learning environment must be student oriented and must reflect student decision-making. The establishment of a classroom environment which is conducive to student decision-making had certain implications for both teacher and student. These implecations are:

For the teacher. There were three major changes recommended for the role of the teacher. These are as follows:

(1) The teacher ceased to teach in the traditional manner, namely standing apart at the front of the

room and imparting facts and figures to his students. Instead he moved into the classroom, interacting on an almost equal basis with his students. This type of interaction necessitates a greater awareness of classroom activity and a greater sensitivity to the interdependence of students.

(2) The Mastery Learning Plan demanded a precise ongoing diagnosis of the students learning deficiences and an appropriate prescription of corrective remedial measures. The teacher involved in this program must emphasize diagnosing, prescribing, and advising, in his instructional plan. This requires a precise planning on the part of the teacher.

(3) Because the means of evaluation employed in the Mastery Learning Plan is so unique that the teacher must clearly outline, for both students and parents, the criteria used to determine the student's achievement. It is also the responsibility of the teacher to keep parents, students, and the school administrators informed on the basic nature of the Mastery Learning Plan.

<u>For the student</u>. Students who followed the Mastery Learning Plan experienced many changes in their role. These are as follows:

(1) Students were involved in decision-making which required making of a commitment to complete a certain amount of learning in a period of time suitable to each student. This decision-making process necessitated

a self-evaluation of ability as well as other personal commitments. On a day to day basis, students involved in the programme were required to make decisions as to what to learn as well as how to learn. Consult Figure 1 for comparison of decision-making processes in the Mastery Learning Plan and the traditional learning procedure.

(2) Because the students were involved in the decision-making process they were also responsible for carrying out their decisions. This meant that the students had to exercise greater self-discipline in the Mastery Learning classroom than in the traditional learning classroom. That is, the discipline in the classroom became more of the student's problem than the teacher's.

(3) The students were involved in deciding what they wanted to learn on any given day, therefore they were responsible for seeking the necessary instructional help. It was up to the student to decide whether to seek help from the teacher, another student or from resource materials. Since each student was responsible for seeking remedial or corrective measures, either from other students or from the teacher, the student had to make a continuous self-evaluation of his learning. To seek remedial or corrective measures meant the student was continuously motivated for self-improvement. The self-evaluation of daily learning made it necessary for the student to obtain feedback on learning deficiences from the teacher. This meant closer interaction between student

and teacher as well as student and student. It is important to note that more often than not it was the student who decided whether to interact with other students or with the teacher. The average and the fast learner quite frequently assumed the role of a teacher in providing remedial help to his fellow students.

SUGGESTIONS FOR FURTHER STUDY

The analysis of data revealed that students who followed the Mastery Learning Plan benefited significantly in achievement and attitude. It was felt that the gain in achievement may have been due to the fact that the Mastery Learning Plan provided greater student-teacher, and student-student interaction. It is, therefore, suggested that further research be carried out to determine the effect of classroom interactions on student achievement. Further, it was felt that the improvement in attitude may have been due to the fact that the Mastery Learning Plan necessitated that students accept a greater responsibility for decision-making in terms of learning activities. It is suggested, therefore, that further research be carried out to determine the effect of student responsibility for decision-making on attitude. Finally, it is recommended that the key ideas of the Mastery Learning Plan be tested by other researchers in order to determine if the results are parallel to this study.

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APPENDIX A

CHEMICAL REACTION (I): A SAMPLE UNIT

SELF-TEST

UNIT TEST #1

UNIT TEST #2

UNIT TEST #3

CHEMICAL REACTION

Prepared by: M. Patel

CHEMISTRY

<u>Purpose</u>

What do atoms and molecules do when they go out to enjoy themselves? What else is there to do but react?

So far we have been preparing ourselves to be able to communicate and interpret chemical information. Let us shift our attention to the more exciting part of chemistry.

From time immemorial chemical reactions of one type or another have been taking place every second in this universe. Some reactions are easy to detect whereas others are very difficult. But why should we study chemical reactions?

Chemical reactions are taking place in plants by which plants produce food for us. Similar reactions are taking place in our bodies whereby we derive energy to do a variety of tasks. While plants are busy producing food, the human race is busily piling up garbage, chemical reactions change the garbage into the poisons that destroy various forms of life on earth. In order to stop poisonous pollutants from gathering and destroying the environment we have to first identify, understand, and then be able to control the various reactions. It is only through the understanding of chemical reactions that, we as a human race will be able to survive through the controlled use of various chemical reactions.

In this unit the student will be made aware of the importance for understanding chemical reactions. The student will apply knowledge gained from the previous units in order to write chemical reactions and to balance them with respect to the Law of Conservation of Mass. Laboratory skills will also be stressed during experimental investigations.

Objectives:

1. You should be able to suggest reasons for studying chemical reactions.
2. Given observeable changes, the student will be able to distinguish between chemical and physical changes.
3. Given the name of reactants and products you should be able to write a chemical equation to represent the chemical reaction.
4. Given a chemical equation you should be able to balance the equation in terms of atoms.
5. Given an experimental data you should be able to deduce
   a. Law of Conservation of Mass.
   b. Write a chemical equation to represent the reaction.
6. You should acquire the following laboratory skills:
   a. To carry out pre and post laboratory calculations.
   b. To carry out outlined experimental procedures with some common sense.
   c. To record all observations accurately.
   d. To maintain proper laboratory safety and neatness during the experiment.

Unit VI Outline

Concepts	Reading	Practice Exercise	Lab.
Writing of Chemical equations for reactions	Chemistry: An Experimental Science, pp. 41-42	Foundations of Chemistry, pp.108, #1, 6	Experiment: As given in the Unit VI Outline
Conservation of Mass in a Chemical reaction	Chemistry: An Experimental Science, pp. 40-41	Chemistry: An Experimental Science, p. 45, #2, 3, 4, 5 and 7	Lab. Experiment: Chemistry: An Experimental Science Lab. Manual pp. 126-127
Balancing of chemical equations	Chemistry: An Experimental Science, pp. 42 Foundations of Chemistry, pp. 84-88	Chemistry: An Experimental Science, pp. 45-46, #9 and 10 Foundations of Chemistry, pp. 108, #2, 3 and 4	

CHEMISTRY

I. <u>Chemical Equation</u> -- A symbolic representation of a chemical reaction.

A chemical reaction may occur whenever atoms or molecules of various kinds get together. When atoms of various kinds get together they recombine in a new way. This recombination of atoms produces a new stuff called a product.

For example, salt used on the road during the winter will react with water and the metal parts of your car to produce iron rust. If this process continues, your car will be a pile of junk in a few years. During the process of rusting, atoms of iron, salt, and water, recombine to produce a reddish brown product called iron oxide. In order to understand chemical reactions a chemist has to be able to:

a. detect or identify a chemical reaction and

b. express these changes by means of a chemical equation.

But what criteria does a chemist use to identify a chemical reaction? During a chemical reaction a substance undergoes a chemical change. Earlier we learned that a chemical change is identified by (1) a change in color, (2) change in odour, (3) change in physical state associated with the production of solid, liquid or gas, which are chemically different substances, (4) changes in temperature. Any combination of the above changes can be used to detect the occurance of a chemical reaction.

Once a chemical reaction has been detected then one must be able to identify the reactant(s) and the product(s) in that reaction. Now the chemist is ready to express the chemical reaction in terms of word equation or a symbolic chemical equation.

Let us study some of the more common chemical reactions and see if we can write a chemical equation to represent various chemical reactions.

<u>Example I.</u>

When Magnesium metal burns in Oxygen gas a white ash called Magnesium Oxide is produced.

To write a chemical equation one must <u>first</u> identify the name and the chemical formula for the reactants. Magnesium metal and Oxygen gas are the substances which are reacting, therefore, Magnesium metal and the Oxygen gas are reactants. The chemical symbol for Magnesium metal is "Mg". The chemical symbol for Oxygen gas is "O_2".

The white ash, called Magnesium Oxide, is called the product. The chemical fomula for the Magnesium Oxide is "MgO". In order to write the chemical equation the chemical symbols for the reactants are placed on the left hand side. Each reactant is separated by a plus sign; the chemical symbol for the product is placed on the right hand side of an arrow. This is expressed as:

$$Mg + O_2 \longrightarrow MgO$$

Reactants yield Products

Example II.

When Carbon burns in Oxygen gas Carbon Dioxide gas and heat are produced.

Carbon and Oxygen gas are reactants.

Carbon Dioxide gas and heat are products.

Carbon = C   Carbon Dioxide gas = CO_2

Oxygen gas = O_2 heat = heat or ht.

(left hand side) (right hand side)

$$C + O_2 \longrightarrow CO_2 + heat$$

Reactant   Product

Example III.

When Zinc metal reacts with hydrochloric acid Zinc Chloride and hydrogen gas are produced.

Zinc, "Zn" and hydrochloric acid, "HCl" -- reactants.

Zinc Chloride, "$ZnCl_2$" and hydrogen gas "H_2" -- products.

$$Zn + HCl \longrightarrow ZnCl_2 + H_2$$

Reactants   Products

Experiment IV

Objective: To detect chemical reactions in terms of various observable changes. To write word and symbolic chemical equations to represent a chemical reaction.

Materials: 5 13mm x 100mm test tubes, 1 test tube rack, 10 ml graduated cylinder 0.1 M lead nitrate, $Pb(NO_3)_2$, 0.1 M Barium Chloride, $BaCl_2$, 1.0 M Sodium Carbonate, Na_2CO_3, 0.1 M hydrochloric acid HCl, 0.1 M Sodium Sulfate Na_2SO_4, 0.1 M Sodium hydroxide, NaOH, Brom-thymol blue indicator solution.

Procedure: Clean and label test tubes from 1 to 5.

Test Tube #1: Place 5 ml of 0.1 M $Pb(NO_3)_2$ and 1 ml of 0.1 Na_2SO_4. Record your observations.

Test Tube #2: Place 5 ml of 0.1 M Na_2CO_3 and 1 ml of 0.1 M HCl. Record your observations.

Test Tube #3: Place 5 ml of 0.1 M $BaCl_2$ and 1 ml of 0.1 M Na_2SO_4. Record your observations.

Test Tube #4: Place 5 ml of 0.1 HCl and 1 ml of 0.1 M NaOH. Record your observations.

Test Tube #5: Place 5 ml of 0.1 M HCl, add one drop of Brom-thymol blue solution. Then add drop by drop 0.1 M NaOH until you can see a visible evidence that a chemical reaction has taken place.

Observations: Record your observations in terms of change in color, production of solid and/or gas, and any other visible evidence that you may encounter.

CHEMISTRY

Test Tube	Observation
1	
2	
3	
4	
5	

Follow up Questions:

Write a word equation to represent a possible chemical reaction in each of the five test tubes.

Write a chemical equation in terms of symbols for a possible chemical reaction in each of the five test tubes.

Identify the name and formula of reactants and products in each of the five test tubes.

II. Law of Conservation of Mass.

Remember in lab. #5 you reacted Lead Nitrate with Potassium Chromate? After the reaction you isolated two substances, namely Lead Chromate and Potassium Nitrate. By now you probably have found that the sum of the weight of lead nitrate and potassium chromate, bearing in mind any experimental error, is equal to the sum of the weight of the orange solid lead chromate and white solid Potassium Nitrate. Do you know the reason why the total weight of the reactants is equal to the total weight of the products? If you recall Dalton's atomic theory it states that during a chemical reaction atoms merely recombine to form new substances. The atoms of lead, nitrogen, oxygen, chromium and potassium that you started with were still present in the product. The only difference is that they have different partners. This is just like the western square dance in which the total number of people remain the same during the dance but the individuals of a given pair changes from time to time. This may be a very far fetched example but the general idea is that just like the individual person changes hands during the course of a dance, similarly, the atoms change hands during the course of a reaction. The main idea is that the total number of atoms in a chemical reaction remains constant. Since each atom has its own specific mass and that the total number of atoms remains constant, therefore, the total mass of the atoms must also remain constant. The principle which states that during a chemical reaction the total mass of reactants must be equal to the total mass of the products. This principle is called the law of Conservation of Mass. This law of Conservation of Mass also implies that atoms are neither created nor lost during a chemical reaction.

III. Balancing Chemical Reaction Equations.

Earlier we used an example of a chemical reaction in which Magnesium metal burns in Oxygen gas to produce Magnesium Oxide. We wrote the equation to represent this as:

$$Mg + O_2 \longrightarrow MgO$$

1 atom + 2 atoms   1 atom + 1 atom = 2 atoms

3 atoms

Let us interprete this equation. The equation states that we reacted one atom to Magnesium with two atoms of oxygen, represented as "O_2", and we received Magnesium Oxide in which there is one atom of Magnesium and one atom of Oxygen. In other words, we have all together three atoms on the reactant side but we have only two atoms on the product side. We have lost one atom of Oxygen but according to the law of Conservation of Mass atoms cannot be lost during a chemical reaction. How can we correct this situation? Before we do anything we must bear in mind that we cannot change the ratio in which atoms combine to form a given compound. For example, it has been shown by chemical analysis that the ratio of Magnesium to Oxygen in Magnesium Oxide is one to one. Therefore, the formula for Magnesium Oxide must remain "MgO" and you and I cannot change or tamper with this ratio. Similarly the formula for Oxygen gas is O_2 and we cannot change that ratio in the formula. However, we can do something else to correct the imbalance of atoms in a chemical equation. This is what can be done.

Step 1. We can start with two Magnesium atoms instead of one. This means we will have two molecules of Magnesium Oxide.

$$2\ Mg + O_2 \longrightarrow 2\ MgO$$

That is, we now have the coefficient "2" in front of "Mg" and "MgO". The coefficient "2" in front of "MgO" means that there are two molecules of Magnesium Oxide. Each containing one atom of Magnesium and one atom of Oxygen.

Now, we see what we have --

2 atoms of Mg + 2 atoms of Oxygen = 4 atoms.

2 atoms on the reactant side.

2 atoms of Magnesium + 2 atoms of Oxygen = 4 atoms on the product side. The law of Conservation of atoms is in good order. That is:

$$2\ Mg + O_2 \longrightarrow 2\ MgO$$

2 atoms + 2 atoms = 2 atoms of Mg + 2 atoms of oxygen

Let us do some similar balancing of Chemical equations.

Example I.

Consider the following equation:

$$2H_2 + O_2 \longrightarrow 2H_2O$$

4 H atoms	4 H atoms
2 O atoms	2 O atoms

Equation 1 is balanced because <u>ATOMS ARE CONSERVED</u>.

Example II.

$$Hg + O_2 \longrightarrow HgO$$

Equation 2 is not balanced. Balance it.

<u>Step One</u>

$$Hg + O_2 \longrightarrow 2HgO \quad \text{(balance O)}$$

<u>Step Two</u>

$$2Hg + O_2 \longrightarrow 2HgO \quad \text{(balance Hg)}$$

Now, <u>ATOMS ARE CONSERVED</u>.

Balance the following:

1. $Mg + O_2 \longrightarrow MgO$
2. $Na + O_2 \longrightarrow Na_2O$
3. $Ca + Cl_2 \longrightarrow CaCl_2$
4. $Al + F_2 \longrightarrow AlF_3$
5. $H_2 + F_2 \longrightarrow HF$
6. $C + H_2 \longrightarrow C_2H_{10}$
7. $HCl + Ca(OH)_2 \longrightarrow CaCl_2 + H_2O$

An equation in Example I can read as:

2 hydrogen molecules plus 1 oxygen molecule reacts to give 2 water molecules.

or

2 moles of hydrogen molecules plus 1 mole of oxygen molecules reacts to give 2 moles of water molecules.

Now, read this equation as above:

$$2C + 3H_2 \longrightarrow C_2H_6$$

Assignment I

I. Write a chemical equation for the following chemical reactions:

a. Magnesium metal reacts with hydrochloric acid to produce magnesium Chloride and Hydrogen gas.

b. Sodium Hydroxide and Carbonic acid reacts to produce Sodium Carbonate and water.

c. Calcium Oxide and Nitric Acid reacts to produce Calcium Nitrate and water.

d. Ferrous bromide reacts with Bromine gas, Br_2 to produce Ferric Bromide.

e. Tin (IV) Chloride reacts with water to produce Tin (IV) Hydroxide and hydrochloric acid.

II. Balance the following equations:

a. $Na_2CO_3 + HCl \longrightarrow NaCl + H_2O + CO_2$

b. $Al + CuSO_4 \longrightarrow Al_2(SO_4)_3 + Cu$

c. $FeS_2 + O_2 \longrightarrow Fe_2O_3 + SO_2$

d. $CaH_2 + H_2O \longrightarrow Ca(OH)_2 + H_2$

e. $AgNO_3 + Na_2CrO_4 \longrightarrow Ag_2CrO_4 + NaNO_3$

III. The following question is based on the Laboratory Experiment #5.

0.284 grams of sodium sulfate is dissolved in 100 ml. of water in beaker #1.

0.522 grams of Barium Nitrate is dissolved in 100 ml. of water in beaker #2.

The last two solutions were mixed and allowed to react. A white solid was observed during the reaction. The solid was filtered, dried and weighed. The filtrate was evaporated and weighed,
The weight of the white solid called $BaSO_4$ is .466 grams. The weight of evaporated product called Sodium Nitarate is .34 grams.

Answer the following questions based on the above information.

a. Calculate the moles of each reactant.

b. Calculate the moles of each product.

c. Using the moles of reactant and product as the coefficient write a chemical equation to represent the reaction.

d. Show how the Law of Conservation of Mass is applied to the above reaction.

e. Are the moles being conserved in this reaction?

Assignment II

1. Write the following equation for the following chemical reactions:

a. Strontium Nitrate reacts with Potassium Sulfate to produce Potassium Nitrate and Strontium Sulfate.

b. Silver Carbonate reacts with Sodium Chloride to produce Silver Chloride and Sodium Carbonate.

c. Ammonium hydroxide reacts with Nitric acid to produce water and Ammonium Nitrate.

d. Potassium Hydroxide reacts with Sulfuric acid to produce water and Potassium Sulfate.

e. Ammonium Phosphate reacts with Magnesium Nitrate to produce Ammonium Nitrate and Magnesium Sulfate.

2. Balance the following equations:

a. $Al + Cu(NO_3)_2 \longrightarrow Al(NO_3)_3 + Cu$

b. $H_3PO_4 + Ba(OH)_2 \longrightarrow H_2O + Ba_3(PO_4)_2$

c. $C_3H_8 + O_2 \longrightarrow CO_2 + H_2O$

d. $Na_2SO_3 + H_2SO_4 \longrightarrow NaHSO_4 + H_2O + SO_2$

e. $P_4 + I_2 \longrightarrow PI_3$

Assignment II

3. A laboratory experiment similar to the laboratory Experiment #5 is performed and the following data is obtained.

3.25 grams of $Pb(C_2H_3O_2)_2$ was dissolved in 50 ml of water in beaker #1.

0.78 grams of Na_2S was dissolved in 50 ml of water in beaker #2.

When the two solutions were allowed to react a solid product called Lead Sulfide was observed.

The Lead Sulfide precipitate was filtered, dried and weighed.

The solution was evaporated and the residual product called sodium acetate was weighed.

The weight of solid Lead Sulfide = 2.39 g.
The weight of solid Sodium Acetate = 1.64 g.

a. Calculate the total number of moles of reactants involved.

b. Calculate the total number of moles of product formed.

c. Are the moles conserved in this reaction?

d. Write a chemical equation using moles as a coefficient for each substance involved in this reaction.

CHEMISTRY

Assignment III

I. Write a chemical equation to represent the following reactions.

a. Zinc Chloride reacts with Silver Nitrate to produce Silver Chloride and Zinc Nitrate.

b. Potassium Chlorate upon heating decomposes to produce Potassium Chloride and Oxygen gas.

c. Perchloric Acid reacts with Sodium Hydroxide to form water and Sodium Perchlorate.

d. Acetic Acid reacts with Potassium Hydroxide to form water and Potassium acetate.

e. Copper(I)Nitate reacts with Sodium Bromide to form Copper(I)Bromide and Sodium Nitrate.

II. Balance the following equations.

a. $Fe_2(SO_4)_3 + K_4Fe(CN)_6 \longrightarrow Fe_4\left[Fe(CN)_6\right]_3 + K_2SO_4$

b. $H_5IO_6 + \text{heat} \longrightarrow I_2O_5 + H_2O$

c. $H_3PO_4 + (NH_4)_2\ NoO_4 + HNO_3 \longrightarrow (NH_4)_3PO_4(MoO_3)_2 + NH_4NO_3 + H_2O$

d. $C_6H_{12}O_6 \longrightarrow C_2H_5OH + CO_2$

e. $FeS + HCl \longrightarrow FeCl_2 + H_2S$

Self-Test

I. Write a chemical equation for the following aqueous solutions:

a. Aluminum Nitrate and Ammonium Fluoride.

b. Iron(II)Chloride and Potassium Carbonate.

c. Stannic Nitrate and Sodium Hydroxide.

II. Balance the following chemical equations:

a. $Al_2(CO_3)_3 + H_2O \longrightarrow Al(OH)_3 + H_2O + CO_2$

b. $KOH + Cl_2 \longrightarrow KClO_3 + KCl + H_2O$

c. $CaC_2 + H_2O \longrightarrow Ca(OH)_2 + C_2H_2$

Question III is based on an experiment similar to Experiment #5.

III. 0.017 grams of silver nitrate was dissolved in 25 ml of distilled water in beaker #1.

0.0059 grams of sodium cyanide is dissolved in 25 ml of distilled water in beaker #2.

When the two solutions were mixed a white solid was observed in the solution.

The solution was filtered and two products were separated and weighed. The following is the weight of each product:

.0134 grams of Silver Cyanide.

.0085 grams of Sodium Nitrate.

a. Calculate the number of moles of each of the reactants and products.

b. Are the moles conserved in this reaction? Explain your answer.

c. Write a chemical equation using the moles as the coefficient of the reaction.

d. Balance the above chemical equation.

CHEMICAL REACTION

Test #1

I. Write a chemical equation for the following aqueous solutions:

a. Barium Chloride and Potassium Chromate.

b. Tin(II)Acetate and Sodium Hydroxide.

c. Silver Nitrate and Potassium Bromide.

II. Balance the following chemical equations:

a. $Al_4C_3 + H_2O \longrightarrow Al(OH)_3 + CH_4$

b. $Na_2CO_3 + H_3PO_4 \longrightarrow Na_3PO_4 + H_2O + CO_2$

c. $Al + H_2SO_4 \longrightarrow Al_2(SO_4)_3 + H_2O + SO_2$

Question III is based on an experiment similar to Experiment #5.

III. 0.189 grams of Zinc Nitrate is dissolved in 25 ml of distilled water in beaker #1.

0.106 grams of Sodium Carbonate dissolved in 25 ml of distilled water in beaker #2.

When the two solutions were mixed a white solid was observed in the mixture. The solution was filtered to separate the two products. The following is the weight of each product.

0.125 grams of Zinc Carbonate.

0.170 grams of Sodium Nitrate.

a. Calculate the number of moles of each reactant and product.

b. Write a chemical equation using the moles as the coefficient of the chemical equation.

c. Balance the above chemical equation.

d. Are the moles conserved and give reason for your answer.

e. Atoms conserved and why.

CHEMICAL REACTION

Test #2

I. Write a chemical equation for the following aqueous solutions:

a. Magnesium Nitrate and Sodium Carbonate.

b. Iron(II)Nitrate and Ammonium Cyanide.

c. Lead Nitrate and Sodium Chloride.

II. Balance the following chemical equations:

a. $C_{10}H_{16} + Cl_2 \longrightarrow HCl + C$

b. $NaI + MnO_2 + H_2SO_4 \longrightarrow Na_2SO_4 + H_2O + I_2 + MnSO_4$

c. $CaC_2 + H_2O + H_2O \longrightarrow Ca(OH)_2 + C_2H_2$

Question III is based on an experiment similar to Experiment #5.

III. .261 grams of Barium Nitrate is dissolved in 25 ml of distilled water in beaker #1.

.084 grams of Sodium Fluoride is dissolved in 25 ml of distilled water in beaker #2.

When the two solutions were allowed to react a white solid was observed in the mixture. The solid product was isolated and weighed. Similarly the filtrate was evaporated and the product was weighed.

The following is the weight of the product:

.175 grams of Barium Fluoride.

.170 grams of Sodium Nitrate.

a. Calculate the number of moles of each of the reactants and products.

b. Write a chemical equation using moles as the coefficient of the chemical equation.

c. Balance the above chemical equation.

d. Are the moles conserved and give reason for your answer.

e. Atoms conserved and why.

CHEMICAL REACTION

Test #3

I. Write a chemical equation for the following aqueous solutions:

a. Barium Chloride and Potassium Chromate.

b. Tin(II)Acetate and Sodium Hydroxide.

c. Silver Nitrate and Potassium Bromide.

II. Balance the following chemical equations:

a. $Al_4C_3 + H_2O \longrightarrow Al(OH)_3 + CH_4$

b. $Na_2CO_3 + H_3PO_4 \longrightarrow Na_3PO_4 + H_2O + CO_2$

c. $Al + H_2SO_4 \longrightarrow Al_2(SO_4)_3 + H_2O + SO_2$

Question III is based on an experiment similar to Experiment #5.

III. 0.189 grams of Zinc Nitrate is dissolved in 25 ml of distilled water in beaker #1.

0.106 grams of Sodium Carbonate dissolved in 25 ml of distilled water in beaker #2.

When the two solutions were mixed a white solid was observed in the mixture. The solution was filtered to separate the two products. The following is the weight of each product.

0.184 grams of Zinc Carbonate.

0.170 grams of Sodium Nitrate.

a. Calculate the number of moles of each reactant and product.

b. Write a chemical equation using the moles as the coefficient of the chemical equation.

c. Balance the above chemical equation.

APPENDIX B

CHEMISTRY ATTITUDE TEST

ANSWER SHEET

NAME: ____________________

DIRECTIONS:

Each of the statements of this opinionaire expresses a feeling which a particular person has toward science. You are to express, on a five point scale, the extent of agreement between the feeling expressed in each statement and your own personal feeling. The five choices are:

Strongly Disagree	S.D.
Disagree	D.
Undecided	U.
Agree	A.
Strongly Agree	S.A.

You are to encircle the letter(s) which best indicates how closely you agree or disagree with the feeling expressed in each statement AS IT CONCERNS YOU.

1. I am always under a terrible strain in a chemistry class.
2. I do not like chemistry, and it scares me to have to take it.
3. Chemistry is very interesting to me, and I enjoy chemistry courses.
4. Chemistry is fascinating and fun.
5. Laboratory experiments in chemistry are stimulating to me.

6. The feeling that I have toward chemistry is a good feeling.

7. My mind goes blank, and I am unable to think clearly when working chemistry problems.

8. I feel a sense of insecurity when attempting chemistry.

9. Chemistry makes me feel uncomfortable, restless, irritable and impatient.

10. Chemistry makes me feel secure and at the same time it is stimulating.

11. Chemistry makes me feel as though I am lost in a jungle of scientific formulas and can't find my way out.

12. Chemistry is something I enjoy a great deal.

13. When I hear the word chemistry, I have a feeling of dislike.

14. I approach chemistry with a feeling of hesitation, resulting from a fear of not being able to do science.

15. I really like chemistry.

16. Writing of laboratory reports makes me dislike chemistry.

17. Chemistry teachers make me feel secure in chemistry.

18. Chemistry is a course in school which I have always enjoyed studying.

19. It makes me nervous to even think about having to do a chemistry problem.

20. I have never liked chemistry, and it is my most dreaded subject.

21. My failure in chemistry makes me dislike chemistry.
22. Chemistry is interesting and very practical to me.
23. I am happier in chemistry class than in any other class.
24. I feel at ease in chemistry, and I like it very much.
25. I feel a definite positive reaction to chemistry; it is enjoyable.

CHEMISTRY OPINIONAIRE (answer sheet)

1.	SD	D	U	A	SA
2.	SD	D	U	A	SA
3.	SD	D	U	A	SA
4.	SD	D	U	A	SA
5.	SD	D	U	A	SA
6.	SD	D	U	A	SA
7.	SD	D	U	A	SA
8.	SD	D	U	A	SA
9.	SD	D	U	A	SA
10.	SD	D	U	A	SA
11.	SD	D	U	A	SA
12.	SD	D	U	A	SA
13.	SD	D	U	A	SA
14.	SD	D	U	A	SA
15.	SD	D	U	A	SA
16.	SD	D	U	A	SA
17.	SD	D	U	A	SA
18.	SD	D	U	A	SA
19.	SD	D	U	A	SA
20.	SD	D	U	A	SA
21.	SD	D	U	A	SA
22.	SD	D	U	A	SA
23.	SD	D	U	A	SA
24.	SD	D	U	A	SA
25.	SD	D	U	A	SA

APPENDIX C

CHEMISTRY 200 FINAL EXAM

(An Achievement Test)

WESTDALE SCHOOL

CHEMISTRY 200

FINAL EXAMINATION

EXAMINER: Mr. Patel

DIRECTIONS:	PART A --	50 MULTIPLE CHOICE	100 marks
	PART B --	Problems based on basic principles of Chemistry. You must show your work in order to receive full credit for your answer.	30 marks

TOTAL: 130 marks

PART A:

1. The best name for the substance Pb CrO_4 is:
   a) Lead Chromate
   b) Lead (II) Chromate
   c) Lead Dichromate
   d) Lead (IV) Chromate
2. If 10 grams of Ca Co_3 are dissolved in 100 ml of water molar concentration of the solution is:
   a) 1M
   b) .1M
   c) .01M
   d) .001M
3. The following represent the electronic configuration of two atoms:
   A. $1s^2$ $2s^1$ $2px^1$
   B. $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3px^1$ $2py^1$ $3pz^1$
   If atom A and B formed a compound the formula for the compound would be:
   a) A_3B_2 b) A_2B_3 c) AB d) A_3B
4. Of the element in the list: Na, Mg, Al, Si, P, S, Cl the element with the greatest ionization energy is:
   a) Na b) Al c) Si d) Cl
5. 1.42 grams of Sodium Sulfate is added to 100 ml of 0.1M H_2SO_4. The molarity of SO_4 ion is:
   a) .1M b) .2M c) .3M d) .4M

6. Plutonium $^{239}_{94}Pu$ captures an alpha particle, He^{++}, to form a new radioactive element Z and 2 neutrons, n^1_0. The reaction may be represented as follows:

$$Pu + He \longrightarrow Z + 2n + \text{energy}$$

The atomic number and atomic mass number of Z would most probably be:

a) $^{241}_{96}Z$ b) $^{243}_{94}Z$ c) $^{236}_{96}Z$ d) $^{241}_{94}Z$

The following data is to be used in answering questions 7 and 8.

Nitric acid can be decomposed according to the following equations:

1) $4HNO_{3(g)} \longrightarrow 4NO_{2(g)} + O_{2(g)} + 2H_2O_{(g)}$

The following equations show the synthesis of some compounds from the free elements and their heat of reaction.

2) $\frac{1}{2}N_{2(g)} + O_{2(g)} \longrightarrow NO_{2(g)}$ ΔH = +8.1 kcal/mole NO_2

3) $H_{2(g)} + \frac{1}{2}O_{2(g)} \longrightarrow H_2O_{(g)}$ ΔH = −57.8 kcal/mole H_2O

4) $\frac{1}{2}H_{2(g)} + \frac{1}{2}N_{2(g)} + 3/2\ O_{2(g)} \longrightarrow HNO_{3(g)}$

ΔH = −35.3 kcal/mole HNO_3

7. If 7.000×10^2g of nitrogen gas were placed with 1.76×10^3g of oxygen gas and allowed to react to form NO_2 gas (equation #2) the number of calories of heat involved would be

a) 2.03×10^5 cal b) 4.05×10^5 cal

c) 4.45×10^5 cal d) 8.10×10^5 cal

8. The H in Kcal per mole of HNO_3 consumed in reaction #1 would be:

a) + 58.60 kcal b) + 85 kcal

c) + 14.65 kcal d) + 6.8 kcal

9. The reaction mechanism for the reaction $A_{(g)}$ + 2

$$A_{(g)} + 2B_{(g)} \longrightarrow C_{(g)} + D_{(g)}$$

1) $A_{(g)} + B_{(g)} \longrightarrow AB_{(g)}$ (slow)

2) $AB_{(g)} + B_{(g)} \longrightarrow C_{(g)} + D_{(g)}$ (fast)

Which of the following statements about the above data is correct?

a) An increase in A affects the rate of reaction more than an equal increase in B .

b) An increase in pressure would result in a decrease in the rate of production of C and D.

c) An increase in A has about the same effect on the reaction rate as an equal increase in B .

d) A decrease in B has more effect on the reaction rate than an equal decrease in A .

10. 22.4 liters of oxygen gas at STP will contain same number of atoms as:

a) 11.2 of NH_3 at STP

b) 22.4 of Helium gas at STP

c) 22.4 of Carbon Dioxide gas at STP

d) 44.8 of Helium gas at STP

11. Consider the following nuclear equation:

$${}^{3}_{1}H + {}^{2}_{1}H \longrightarrow {}^{4}_{2}He + {}^{1}_{0}n \qquad H = -4.0 \times 10^{7} \text{ kcal/mole}$$

Which of the following statements is TRUE?

a) This reaction is endothermic.

b) The helium atom and neutron produced have less energy than the reactants.

c) This reaction is a nuclear reaction called fission.

d) The total number of electrons in the products is less than the total number in the reactants.

12. If 40.0 ml of a solution of 1.0×10^{-4} HCl are mixed with 60.0 ml of a solution of 1.0×10^{-3}M HCl the H^+ concentration of the mixture is:

a) 3.5×10^{-3M}

b) 3.5×10^{-3}M

c) 4.6×10^{-3}M

d) 6.4×10^{-3}M

13. Increasing the temperature of a chemical reaction usually increases the overall rate. The MAIN reason is believed to be that:

a) there are more molecular collisions

b) the activation energy barrier is lowered

c) more molecules have energy equal to or exceeding the threshold energy

d) the activated complex becomes simpler in structure

14. According to the Quantum Mechanics view of an atom, an orbital is defined as:

a) The Path of the electron around the nucleus

b) The shape of the electron orbit

c) The region around the nucleus representing the average probability of finding an electron

d) The motion of the electron around the nucleus

15. An atom has an atomic Number of 24. Its ground state electronic configuration is:

a) $1s^2$ $2s^2$ $2p^6$ $3s^2$ sp^6 $4s^2$ $3d^4$

b) $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $3d^4$ $4s^2$

c) $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $4s^2$ $4p^4$

d) $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $3d^6$

16. One atom of element X weights 5.15×10^{-23}g. The element X is

a) Cl b) S c) P d) Si

17. Which statement is not true of absolute zero?

a) It is the lowest possible temperature.

b) It is zero on the Celsius thermometer.

c) It is equal to $-273^{\circ}C$

d) It is the temperature at which gas molecules have no kinetic energy.

18. The Magnesium ion Mg^{++} has the same number of electrons as each of those listed below except:

a) Na^+ b) Be^{++} c) F^- d) $O^=$

19. In a closed container, there are 32.0 grams of <u>each</u> of oxygen gas, O_2, sulfur dioxide gas, SO_2 and methane gas. The total pressures of these three gases is 700 mm of Hg. Partial pressure of methane gas is:

a) 100mm b) 233 mm c) 312 mm d) 400 mm

20. In an experiment it was found that mixing equal volumes of 0.1 solutions of $FeCl_3$ and NaOH produced a precipitate of $Fe(OH)_3$.

Which of the following equations best represents the net ionic equation for the reaction?

a) $Fe^{+3}(aq) + 3\ OH^-(aq) \longrightarrow Fe(OH)_3(s)$

b) $Fe^{+3}(aq) + 3\ Cl^-(aq) + 3\ Na^+(aq) + 3\ OH^-(ag) =$
$Fe^{+3}(aq) + 3\ Cl^-(aq) + 3\ Na^+(aq) + 3\ OH^-(aq)$

c) $FeCl_3(aq) + 3\ NaOH(aq) = Fe(OH)_3(s) + 3\ NaCl\ (aq)$

d) $Fe^{+3}(aq) + 3\ Cl^-(aq) + 3\ NaOH(aq) = Fe(OH)_3(s) +$
$3\ Na^+(aq) + 3\ Cl^-(aq)$

21. A gas has a volume of 4 liters at 25°C. and 760 mm pressure. In order to double the volume of the gas at 760 mm pressure the temperature will have to become:

a) 596°C b) 50°C c) 323°C d) 546°C

22. The total or maximum number of electrons which an atom can have if the atom has 'n' number of energy orbitals is:

a) n b) 2n c) n^2 d) $2n^2$

23. Two isotopes have:

a) The same atomic number but different mass number

b) Same atomic number and the same atomic mass

c) Different atomic number and different atomic mass

d) The same atomic mass and the same mass number

24. Which of the following chemical equation is right:

a) $2Mg + H_2O \longrightarrow Mg_2OH + H_{2(g)}$

b) $Mg + H_2O \longrightarrow Mg^+ + H_2 + \frac{1}{2}O_{2(g)}$

c) $Mg + 2H_2O \longrightarrow Mg_2 (OH)_2 + H_{2(g)}$

d) $Mg + 2H_2O \longrightarrow Mg(OH)_2 + H_{2(g)}$

25. Which of the following pairs of substance would you predict which would not produce a precipitate when equal volumes of their 0.1 M solutions are mixed:

a) $Pb(NO_3)_2(aq)$ and $Na_2SO_4(aq)$

b) $Pb(NO_3)_2(aq)$ and $NaI_2(aq)$

c) $Pb(NO_3)_2$ and $NaCl$ (aq)

d) $Pb(NO_3)_2$ and $NaNO_3(aq)$

26. A sample of carbon dioxide gas weighs 2.42 grams. An equal volume of another gas under the same conditions weighed 5.55 grams. The weight of one mole of the unknown gas at STP would be:

a) 164 grams b) 100 grams

c) 69 grams d) 24.6 grams

27. The atomic number of Scandium is 21. Which of the following statements concerning Scandium is NOT known from this information?

a) A neutral atom of Scandium has 21 electrons

b) The nuclear charge of Scandium atom is plus 21

c) There are always 21 neutrons in the Scandium atom

d) There are 21 protons in the Scandium atom

Use the following information to answer questions 28 through 30.

$$2C_2H_{2(g)} + 5\ O_{2(g)} \longrightarrow 4CO_{2(g)} + 2H_2O_{(g)} + 620 \text{ kcal.}$$

28. The heat produced per mole of C_2H_2 is:

a) 320 k.cal. b) 310 k.cal.

c) 155 k.cal. d) 62 k.cal.

29. If 1.04 grams of C_2H_2 were burned in the above equation the amount of heat produced would be:

a) 62 k.cal. b) 32 k.cal.

c) 12.4 k.cal d) 6.2 k.cal

30. If 1.04 grams of C_2H_2 were burned the number of molecules of H_2O produced would be:

a) 0.72 grams of water

b) 2.4×10^{22} molecules of water

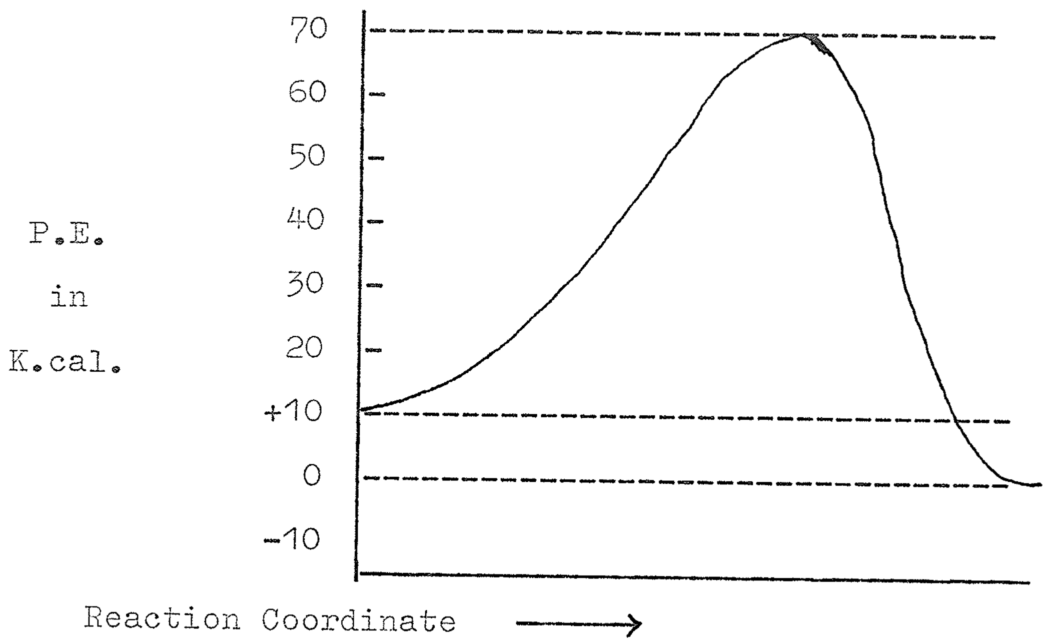
c) 0.2 molecules of water

d) 6.02×10^{21} molecules of water

The following is a graph representing the reaction between

$$H_{2(g)} + I_{2(g)} \longrightarrow 2HI_{(g)}$$

Use the graph to answer questions 31 through 33.



31. The $\Delta H_R^{\ddagger}$ for $H_{2(g)} + I_{2(g)} \longrightarrow 2HI_{(g)}$

a) + 70 Kcal

b) + 60 Kcal

c) - 60 Kcal

d) - 70 Kcal

32. The $\Delta H_L^{\ddagger}$ for $H_{2(g)} + I_{2(g)} \longrightarrow 2HI_{(g)}$

a) + 70 Kcal

b) + 60 Kcal

c) - 60 Kcal

d) - 70 Kcal

33. ΔH is

a) + 20 Kcal

b) - 20 Kcal

c) + 10 Kcal

d) - 10 Kcal

34. The density of 18M Phosphoric Acid, H_3PO_4 in grams per 100 cm^3 is:

a) 1764g/100 cm^3

b) 176.4g/100 cm^3

c) 900g/100 cm^3

d) 90g/100 cm^3

35. $Ag^+(ag) + NO_{3(ag)}^- + Na_{(ag)}^+ + Cl_{(ag)}^- \longrightarrow AgCl + Na^+(ag) + NO_{3(ag)}^-$

What volume of 0.2 M Sodium Chloride solution would be required to precipitate all of the silver out of 25 ml of 1.2 M Silver Nitrate solution

a) 4.25 ml b) 5.0 ml c) 25 ml d) 150 ml

36. If the temperature, pressure and volume are the same, then 14 grams of nitrogen gas will have the same number of molecules as:

a) 32 grams of oxygen gas

b) 34 grams of Ammonia gas

c) 71 grams of Chlorine gas

d) 15 grams of Nitric Oxide gas

Use the following information to answer questions 37 through 39.

The following is a <u>model</u> describing the behavior of gas molecules in a container filled with Nitrogen gas at 25°C.

A small cylinder with a movable piston is evacuated and filled with some small metal spheres. Imagine the spheres are in continuous random motion. After each collision the spheres rebound without any loss of energy of motion.

37. In order for the above model to be similar to the Nitrogen gas system what must happen to the <u>metal spheres</u> if the temperature is increased.

a) They will collide with each other more frequently.

b) They will have more kinetic energy.

c) They will collide with the piston more frequently.

d) All of the above.

38. What would happen to the piston if the temperature is decreased.

a) The piston would move upward.

b) The piston would not move at all.

c) The piston would move downward.

d) The molecules will have more kinetic energy, therefore, they will hit the piston more frequently.

39. The spheres inside the cylinder were replaced by larger spheres and the temperature and the volume were kept constant. What effect would this change have upon the pressure?

a) The pressure would increase.

b) The pressure would remain the same as before.

c) The pressure would decrease.

d) None of the above.

40. 10 grams of hydrogen gas and 16 grams of oxygen gas is allowed to react to produce H_2O. How many grams of water is produced?

a) 90 grams b) 45 grams

c) 18 grams d) 10 grams

41. What volume of hydrogen gas at STP will be required to produce 340 grams of ammonia?

$$H_{2g} + 3H_{2(g)} \longrightarrow NH_{3(g)}$$

a) 224 b) 448 c) 672 d) none of these

Questions 42 and 43 refer to the following data obtained from Experiment #12, Heat of Reaction -- Neutralization:

A clean dry erlenmeyer flask was weighed 100 ml of 0.50 M HCl was placed in the flask. 100 ml of 0.50 M KOH was measured. The temperature of both the acid and base solution was taken. The two solutions were mixed and the final temperature taken.

Observations:

The total original temperature was	20.1°C
The original temperature of KOH was	10.1°C
The final temperature of mixture was	22.5°C
The weight of the flask was	125 gm.

42. If the specific heat of the solutions is 1 calorie per gram per centigrade degree and the density is 1 gram per milliliter then the total heat absorbed by the liquid is:

a) 240 calories b) 480 calories

c) 540 calories d) 600 calories

43. The total heat liberated by the reaction was 540 calories. The heat of reaction per mole of H^+ is

a) 4.80×10^3 calories b) 6.00×10^3 calories

c) 1.08×10^4 calories d) 5.40×10^5 calories

Questions 44 and 45 refer to the following data obtained in determining the concentration of a NaOH solution:

Assume that oxalic acid ionizes as: $H_2C_2O_4 \longrightarrow 2H^+ + C_2O^=$

	49.0	gm
Weight of beaker	10	gm
Volume of acid solution	500	ml
Volume of acid solution used in titration	16.0	ml
Volume of base used in titration	60.0	ml

44. The concentration of the standard solution is

a) 0.10 M b) 0.20 M c) 1.07 M d) 0.125 M

45. The final concentration of the sodium hydroxide is

a) 0.53 M b) 0.75 M c) 1.07 M d) 0.125 M

Questions 46 through 48 relate to an experiment similar to lab Experiment #16. A strip of metallic zinc, Zn, was weighed and placed in a beaker containing a solution of silver nitrate, $AgNO_3$. The next day, a silvery metallic deposit was present in the beaker. The zinc strip was washed, dried and weighed. The liquid was decanted off the metallic residue which was also washed, dried and weighed. The data obtained are recorded below.

Weight of zinc strips before reaction	14.26 g
Weight of zinc strip after reaction	13.61 g
Weight of silver produced	2.16 g

one mole of zinc weighs 65.4 g

one mole of silver weighs 107.9 g

46. How many moles of zinc reacted?

a) 0.010 mole b) 0.020 mole

c) 0.050 mole d) 0.10 mole e) 0.20 mole

47. How many moles of silver were formed?

a) 0.020 mole b) 0.020 mole

c) 0.050 mole d) 0.10 mole e) 0.20 mole

48. 34 g. of NH_3 are carefully weighed out. All statements concerning the weighed quantity of ammonia are true EXCEPT one. Which statement is WRONG?

a) Two moles of NH_3 are present

b) Six moles of hydrogen atoms are combined with nitrogen atoms to form the ammonia

c) Two moles of nitrogen molecules, N_2, will produce 34 g of NH_3

d) Approximately 12 x 10^{23} molecules of ammonia are present in the container

49. A family of elements (commonly referred to as groups) can be identified by each of the following statements except

a) All elements in the family have the same atomic number

b) Elements are arranged in a vertical column

c) All elements in a family have similar chemical properties

d) All elements in the family generally have the same number of electrons in the outermost orbital

50. Quantum mechanics explains or enables prediction of all EXCEPT one of the following characteristics of atoms. Identify the EXCEPTION.

a) the specific energy levels the electron can occupy

b) the general symmetry of the electron orbitals

c) the frequency of light absorbed or emitted by gaseous atoms

d) the path or trajectory of the electrons

Do two out of the three following questions:

1.A. Nitrogen gas reacts with hydrogen to produce Ammonia gas NH_3.

a) Write a balanced chemical equation to represent the above reaction.

b) If 14 grams of hydrogen gas and 14 grams of nitrogen gas were allowed to react, how many grams of ammonia gas, NH_3 can be produced in this reaction.

B. Carbon solid reacts with Sulfuric Acid to produce Carbon Dioxide gas, water and sulfur dioxide gas.

a) Write a balanced chemical equation for the above reaction.

b) Calculate the volume in liters of 18 M H_2SO_4 that would be required to produce 1000 liters of sulfur dioxide gas at 727°C and 380 mm pressure.

C. Aqueous solution of Lead Acetate is allowed to react with aqueous solution of Ammonium Sulfide.

a) Write a balanced chemical equation to represent the above reaction.

b) Calculate the mass of lead sulfide that can be produced when 100 ml of 0.5 M Ammonium Sulfide has reacted.

2. A sample of gas at 100°K and 200 mm pressure occupy 10 liters. How many liters will the same gas occupy if both the temperature and the pressure were to be doubled?

3. How many milliliters of 0.8 M $BaCl_2$ solution that must be measured out to prepare 250 ml of 0.1 M solution?

Do ONE of the following questions:

4.A. Given the following mixtures of non-reactive gases in a container:

6.02×10^{22} molecules of CH_4 gas

.25 moles of O_2 gas

6.4 grams of SO_2 gas

The total pressure is 450 mm of Mercury.

What is the partial pressure of each gas?

B. Calculate the heat of reaction, ΔH, for:

$2H_2S(g) + 3O_{2(g)} \longrightarrow 2H_2O_{(1)} + 2SO_{2(g)},\ \Delta H = \underline{\ ?\ }$

1) $H_{2(g)} + S_{(s)} \longrightarrow H_2S_{(g)},\ \Delta H + 4.82\ cal_{/mole\ H_2S}$

2) $H_{2(g)} + \frac{1}{2}O_{2(g)} \longrightarrow H_2O_{(1)},\ \Delta H = -68.32\ cal_{/mole\ H_2O}$

3) $S_{(s)} + O_{2(g)} \longrightarrow SO_{1(g)},\ \Delta H = -70.76\ cal_{/mole\ SO_2}$

APPENDIX D

CONTENT ANALYSIS OF THE CHEMISTRY 200

FINAL EXAMINATION

CONTENT ANALYSIS OF CHEMISTRY 200

FINAL EXAMINATION

1. Formulas -- Unit #3
2. Molarity
3. Formula
4. Ionization Energy
5. Molarity
6. Nuclear Reactions
7. Chemical Calculations
8. Heat - H
9. Reaction Rate -- Unit II
10. S.T.P.
11. H
12. Molarity
13. Rate of Reaction
14. Quantum Mechanics
15. Electronic Configuration
16. Avogadro's Number
17. Absolute Zero - K^o
18. Electronic Configuration of Atoms
19. Partial Pressure
10. Net Ionic Equations
21. Gas Laws
22. Orbital
23. Isotopes
24. Quantum Mechanics
25. Chemical Reactions - P.172

26. S.T.P.

27. Atomic Number

28.)
29.) Chemical Calculations
30.)

31.)
32.) Interpretation of Graphs
33.)

34. Density and Molarity

35.)
36.) Avogadro's Hypothesis

37.-40. All Experiment 8-10

41.-44. Titration

45.-48. Heat Reactions Experiment #13

49. Molarity

50. Quantum Mechanics

PROBLEMS:

2 Problems on Molarity

1 Problem on Δ H

2 Problems on Chemical Calculations

1 Problem on Partial Pressure

APPENDIX E

RAW DATA TABLE

CONTROL GROUP

EXPERIMENTAL GROUP

Table 13

Raw Data - The Control Group

Student	Age	IQ	Pre Att.	Pre Ach.	Post Att.	Post Ach.
1	18	97	77	32	68	19
2	16	107	88	26	73	22
3	16	126	88	32	100	60
4	16	128	75	28	62	25
5	16.5	121	95	40	74	40
6	16	102	75	26	68	26
7	16	130	110	32	109	66
8	15	119	106	38	104	50
9	16.5	118	86	32	78	60
10	16	126	98	26	102	65
11	16.5	105	85	16	85	40
12	16.5	103	77	22	86	44
13	16.5	105	98	20	102	53
14	16	128	94	34	94	54
15	16.5	130	78	40	90	77
16	18	102	78	24	71	32
17	15	126	98	36	100	80
18	17	100	89	22	58	32
19	16	103	93	16	90	30
20	16	122	83	24	75	45
21	16	121	80	20	80	48
22	16.5	128	111	32	83	62
23	16.5	119	69	26	70	46

Table 14

Raw Data - The Experimental Group

Student	Age	IQ	Pre Att.	Pre Ach.	Post Att.	Post Ach.
24	17.5	104	110	28	111	58
25	16	120	94	32	100	75
26	17	130	105	30	108	81
27	17.5	108	98	40	98	71
28	17.5	116	81	24	98	50
29	17.5	110	90	26	96	42
30	17.5	118	69	36	85	74
31	18	102	92	16	96	53
32	16	118	94	24	98	84
33	17	108	108	24	112	45
34	17.5	105	79	20	89	40
35	15	130	96	24	103	87
36	17.5	99	97	42	83	68
37	15	116	86	28	97	75
38	15	116	92	28	101	75
39	18	105	59	26	74	45

APPENDIX F

AN APPRAISAL OF THE MASTERY LEARNING PLAN

AN APPRAISAL OF THE MASTERY LEARNING PLAN

The following is a summary of observations on the Mastery Learning Plan.

STRENGTHS:

- The format of the unit plan made implementation of the program quite simple. By preparing a flow chart and stating objectives students are fully aware of the expectations of the instructor. As well, students usually entered the classroom knowing what their daily work plan would be.
- The program seemed particularly suited as a follow up course from IPS.
- Topics presented are in a sequential manner, such that the student is continuously making use of skills learned in each unit.
- The writing sytle is at the students' level.
- Reference materials to supplement the pamphlets are left to the instructor's discretion -- a multi-text approach can be used with the program.

WEAKNESSES:

- It was anticipated that strong students would proceed through units with less difficulty than weak students and, therefore, allow more time for the instructor to work with weaker students. However, strong students tended to require as much time as weaker students, if not more.

- Laboratory exercises written up in the unit were not clear as to intent. Some were too elementary in nature.
- The quantitative approach to chemistry is heavily stressed in the pamphlets, but there is a lack of emphasizing the significance of such an approach.

CONCLUSIONS:

- I have been fully satisfied that this program does offer a valuable method for the teaching of Chemistry. The responsibility placed upon the student serves as an added incentive. The flexibility of the Mastery Learning Plan allowed the instructor to use his own talents in striving for improvement and excellence in instruction.

(sgd.) M. Goldberg