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A Study Comparing the Understanding of Selected Principles of College Chemistry by Intermediate Grade Pupils in Ellensburg and Mercer Island, Washington

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A STUDY COMPARING THE UNDERSTANDING OF SELECTED PRINCIPLES OF COLLEGE CHEMISTRY BY INTERMEDIATE GRADE PUPILS IN ELLENSBURG AND MERCER ISLAND, WASHINGTON

[redacted]

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CHAPTER I

THE PROBLEM, SUBJECTS USED, AND RESEARCH PROCEDURE

Initial interest in the problem of teaching concepts of chemistry to elementary school children was prompted when personal assistance was given to a sixth grade teacher who was teaching a chemistry unit in a Mercer Island, Washington, elementary school. The problem of teaching concepts of chemistry to elementary children in Ellensburg, Washington, was previously investigated by Shrader (45). Interest was increased through discussion with Shrader who had determined that elementary school pupils can understand many "science" ideas to a fair degree of depth. It was decided to conduct a study similar to Shrader's to determine the validity of his results. Some conditions were modified in this investigation.

I. THE PROBLEM

Statement of the problem. It was the purpose of this study (1) to teach the content as identified in the Ellensburg Study to fifth and sixth grade pupils in West Mercer Elementary School; (2) to determine if differences or similarities existed between the Mercer Island and Ellensburg groups; and (3) to develop an attitude scale to reflect pupils' concerns about science.

Limitations of the study. (1) The elementary classes consisted of fifth and sixth grade children; (2) the classes were non-segregated; (3) no attempt was made to compare the fifth with the sixth grade students; (4) the chemistry unit consisted of relatively concrete ideas; and (5) the experimenter was aware of the test used to make the pre and post test evaluation.

II. SUBJECTS USED

Experimental group - The elementary children that received chemistry instruction.

Control group - The elementary children that took the pre and post tests about the same time as the experimental group but did not receive chemistry instruction.

College group - Introductory college chemistry class.

Ellensburg study - Earlier study conducted at Ellensburg, Washington.

Ellensburg experimental group - One fifth and one sixth grade class at Hebeler Elementary School (HES).

Ellensburg control group - One fifth and one sixth grade class at Washington Elementary School.

Ellensburg college group - Introductory college chemistry class at Central Washington State College, Ellensburg, Washington.

Mercer Island Study - This study conducted on Mercer Island, Washington.

Mercer Island experimental group - One fifth and one sixth grade class at West Mercer Elementary School.

Mercer Island control group - One fifth and one sixth grade class at Island Park Elementary School.

Mercer Island college group - Introductory college chemistry class at Bellevue Community in Bellevue, Washington.

III. RESEARCH PROCEDURES

The design used in the Ellensburg Study and generally followed in this research is described below.

> College chemistry texts were studied and content commonly taught during early stages of such courses was identified. The content was organized into a Teaching unit (see Appendix A). The unit included details of chemistry, suggested learning experiences, and required materials. A number of chemistry tests were examined. A pre-test-post-test was developed and consisted of twenty-five multiple choice items (see Appendix B). Lesson plans were developed in detail. Each of the items indicated in this paragraph were checked closely to eliminate inaccuracies and ambiguities.
>
> The test was given to college students on the first lecture day in beginning chemistry. The same test was given at the start of the unit to the experimental groups (fifth and sixth graders at HES). The instructor teaching the unit did not see the test items. The fifth and sixth grade pupils at Washington Elementary School served as the control group and took the same test during the same week as the experimental group.
>
> The unit was taught in general accordance with the original design of the unit and the lesson plans. Notes were made by the instructor when deviations were made in the lesson plans so the revised plans could be included in this report (see Appendix C). The equipment and materials were listed according to particular lessons (see Appendix D).
>
> The test was given to all groups following the teaching of the unit to the experimental group. The college class took the post test towards the end of the first quarter of work. Alanysis of the study and of the data were made. (21:2)

The Mercer Island Study differed from the Ellensburg Study in that (1) West Mercer Elementary School was not a campus school; (2) a community college group was used; (3) an attitude test was devised and given to control and experimental groups; (4) the researcher had seen the pre-post test prior to teaching the unit; and (5) the instructor in the Ellensburg Study had been teaching science to Hebeler Elementary School students throughout the year, whereas the instructor in the Mercer Island Study had no previous contact with West Mercer Elementary students.

Clearance for the study was given by the Mercer Island School District. Permission was obtained to be absent from the high school during my preparation period and immediately after school. The principal at West Mercer Elementary School agreed to the use of one fifth grade class and one sixth grade class as an experimental group. The sixth grade class was to be taught starting at 9:50 A.M. and the fifth grade class starting at 2:30 P.M. The time spent in teaching each class each day ranged from 30 to 50 minutes. The unit was taught during the month of October. The principal at Island Park Elementary School allowed the use of a fifth grade class and a sixth grade class as a control group. This group was tested during the same weeks as the experimental group. The Bellevue Community College instructor allowed his first quarter college chemistry class to be tested during the first week of classes and towards the end of that quarter.

"The evaluation instrument used in pre and post testing of all groups consisted of twenty-five multiple choice items. Each item had four foils. An attempt was made to make each foil plausible. The items were checked carefully by chemists and psychologists to help prevent ambiguity and inaccuracy."

(45)

The scores from the pre and post test were computed as right minus one-third wrong and put on computer cards. The computer was programmed to give (1) the difference between the pre and post test; (2) the average pre test; (3) the average post test; (4) the average difference; (5) the sigma pre test; (6) the sigma post test; and (7) scores comparing the various groups including degrees of freedom.

The test was analyzed for several features. In Appendix A date have been presented showing the number of times a particular idea, term, fact, concept, or principle was touched upon in the test. Some aspects of chemistry were repeatedly tested while others received cursory treatment. The test was designed to try and make commensurate the testing and teaching emphasis.

Each item of the test was analyzed to determine the level of learning tested by the item. The levels of learning used to group the test items were knowledge, comprehension, application, analysis, synthesis and evaluation.(13) Each question was put into one of the categories according to the writers judgment. The analysis was recorded in Table I.

An item analysis was made from the Mercer Island Study. Answer sheets of the fifteen highest and fifteen lowest scoring pupils of the experimental group were used. The date relating to the analysis were included in Table II. An item

TABLE I

RESULTS OF ANALYSIS OF TEST ITEMS AS RELATED TO LEVELS OF LEARNING

Level of learning	The number of each test item as placed in the appropriate category
Knowledge	1, 3, 7, 9, 14, 19, 22
Comprehension	5, 12, 16, 18, 20, 23, 25
Application	4, 11, 21
Analysis	10
Synthesis	3, 6, 8, 13, 15, 17, 24
Evaluation	None

TABLE II

ITEM ANALYSIS USING THE POST TEST SCORES OF THE

MERCER ISLAND EXPERIMENTAL GROUP

Total Experimental Group	55		
Highest Scoring Group	15	Range	15.7 to 23.7
Lowest Scoring Group	15	Range	-0.3 to 8.3

	Highest Fifteen		Lowest Fifteen	
Item	Right	Wrong	Right	Wrong
1	6	8	2	13
2	10	4	4	11
3	10	4	6	9
4	7	7	0	15
5	15	0	11	4
6	14	1	6	8
7	12	3	6	9
8	12	3	6	9
9	14	1	6	9
10	14	1	8	7
11	13	2	6	8
12	13	2	6	9
13	14	1	2	13
14	13	2	10	5
15	12	3	8	7
16	6	9	3	12
17	13	2	5	10
18	13	2	5	10
19	13	2	9	6
20	15	0	4	11
21	7	8	3	12
22	15	0	13	2
23	10	5	4	11
24	15	0	7	8
25	15	0	10	5

analysis in the Ellensburg Study was made using the results of the post test of the experimental group. Answer sheets of the eleven highest and eleven lowest scoring pupils were used. In Table III have been cited the results of the analysis.

In the Ellensburg Study observations of pupil reactions were recorded by the teacher and, when possible, another observer. The observations seemed to provide some basis for comment regarding pupil interest and the advisability of spending prolonged periods on specific areas of science in the elementary school. In Table IV have been included comments taken from the Ellensburg Study. Comments from the Mercer Island Study have been included in Table V.

About one and one-half years after the post testing of the Mercer Island control and experimental groups had been completed, elementary and junior high principals were contacted to locate students from the control and experimental groups. Forty-four students from each group were located. The eighty-eight students were given an attitude test devised by a psychology class at Central Washington State College. The attitude test (Appendix E) was scored by hand, reversing the numerical order of questions 1, 5, 6, 7, 8, 9, 10, 11, 12, and 13, and totaling the points. An F test was applied to the two groups.

TABLE III

ITEM ANALYSIS USING THE POST TEST SCORES OF THE ELLENSBURG EXPERIMENTAL GROUP

	Highest Eleven		Lowest Eleven	
Item	Right	Wrong	Right	Wrong
1	6	4	1	9
2	4	7	0	10
3	8	3	5	5
4	11	0	4	7
5	11	0	8	3
6	9	2	2	7
7	8	3	5	6
8	11	0	4	7
9	11	0	8	2
10	11	0	8	3
11	8	3	2	9
12	5	6	4	7
13	10	1	3	8
14	11	0	10	1
15	8	5	2	7
16	8	5	2	8
17	10	1	3	7
18	6	5	2	7
19	8	3	8	3
20	10	1	0	11
21	7	4	5	6
22	11	0	11	0
23	6	5	1	10
24	10	0	6	5
25	9	2	3	8

TABLE IV

OBSERVATIONS AND COMMENTS BY THE INSTRUCTOR

OF THE EXPERIMENTAL GROUP

1st day -	Both classes showed a high interest and gave full attention. The fifth graders tried to ask questions prior to the pre test.
2nd day -	The sixth graders readily distinguished between matter and non-matter. The fifth graders had difficulty understanding that liquids and gases are matter.
3rd day -	Both classes responded well. Some fifth graders showed considerable interest in the balance and the metric weights. Many students have gone to outside reading and are "ahead" of the program.
4th day -	The lab went smoothly and the pupils were excited. Some fifth graders thought the ideas were too easy, but are working hard and show much interest. Observations had to be directed for some pupils.
5th day -	Satisfactory.
6th day -	The thinking of the sixth grade group had to be led more than with fifth grade. Good interest was shown in the fifth grade.
7th day -	Satisfactory. Most pupils seemed to have a basic understanding of types of matter. The pupils paid close attention to the film, which was quite elementary. The film reports of pupils were very good.
8th day -	The sixth graders seemed to understand the material more quickly than the fifth graders. Sixth graders are more willing to drop ideas which they cannot make hold true and to expand their answers. The alcohol and Crisco do not mix, so the solvent was changed for the fifth grade demonstration.
9th day -	More time seems to be spent with the fifth grade since there is no deadline to meet. Time was

spent explaining thermometers to some fifth graders--not to sixth graders. There seems to be a "snowballing" of interest in science among fifth grade girls. Several sixth grade girls are reviewing the science lessons with a girl transfer.

10th day - The film was excellent. There was apprehension shown about the quiz and there was some evidence of cheating which stopped with an oral warning. The evidence from the quiz seems to show that the pupils are not reviewing their notebooks. No other behavior problems are apparent. Some pupils show impatience with questions and remarks of others.

11th day - The lesson went poorly in the fifth grade. The pupils were unhappy about the quiz grades and the marking of their answers. The sixth graders responded "normally" to quiz papers when they were returned.

12th day - The confusion of the previous day was not exactly as it had appeared. All fifth graders had completed their demonstration sheets while some sixth graders had not. The lesson was very stimulating to both classes. The difficulty with the balance not being as accurate as desired led to discussion. The review apparently helped, and more reviewing each day than has previously been done seems advisable. Several fifth grade girls asked if science is going to be taught in summer school. The regular classroom teacher commented that the pupils seem to be getting a great deal from the unit and that they have a fine attitude towards the work.

13th day - An excellent lesson in both grades, but interest seemed less in the fifth grade. A number of pupils are participating now who did not do so previously. Two pupils in the fifth grade are slowing the class down by unnecessary review questions.

14th day - There were several cases of gross cheating in the fifth grade and the pupils were quite tense. This feeling was absent in the sixth grade. Several items in the quiz were not good and should not have been included.

15th day - The interest was high in both classes but in both classes a number of students did not have a concept of "atom." The methods used in the lesson did not seem satisfactory. Some pupils do not seem to want to learn the names of elements and their symbols.

16th day - There was high interest in the laboratory work. The presentation was slowed and only about one-half of the intended work was completed. The sixth graders generally were not ready for the quiz on symbols, but all the fifth graders had learned them.

17th day - The interest was high in both classes. In spite of the fact that seeds were being used by pupils to make simulated atoms, none were thrown.

18th day - The film was excellent. Both grades were interested in making atomic structures and did not want to stop. The fifth graders worked faster and asked each other to identify atoms they had diagrammed.

19th day - The lesson proceeded well.

20th day - Although the lesson was covered completely, very few pupils seemed to be able to explain the law of definite proportions; but many could make statements which were based upon the law.

21st day - The fifth graders continued to show interest in diagramming elements. The sixth grade pupils lost interest. It is harder to keep a discussion going now, as interest seems to be declining. Although most of the students have learned the elements and symbols, they do not seem to be able to understand the symbols when working with formula of compounds.

22nd day - The lesson went well. The sixth grade pupils were interested in the review of the conservation of matter. The fifth grade pupils seemed to understand the meaning of exo and endothermic.

23rd day - The review seemed to show that pupils had increased their understanding of chemistry. A few pupils are beyond the unit. Some pupils would like to continue the study while others are happy the unit is over and do not care about more learning in this area of science.

24th day - Post test.

TABLE V

OBSERVATIONS AND COMMENTS BY THE INSTRUCTOR OF THE MERCER ISLAND EXPERIMENTAL GROUP

1st day -	The fifth graders asked questions about science, wondered if this test would be part of their science grade and if we would go over the test so they could see what they missed. The sixth graders showed interest, but did not ask questions.
2nd day -	The sixth graders did very well distinguishing between matter and non-matter. The fifth graders had difficulty classifying gases as matter.
3rd day -	The sixth graders realized I was leading to a definition of matter and tried to give it before I was through. Almost everyone had the correct definition. The fifth graders did not individually define matter. It was a group compilation.
4th day -	The classroom was the labroom and it worked out satisfactory. Both groups showed interest.
5th day -	The definitions of solid, liquid and gas were made easily after the demonstrations.
6th day -	The fifth graders enjoyed the demonstrations of matter changing states more than the sixth graders.
7th day -	Both classes paid attention to the film about solids, luquids, and gasses. The sixth graders made comments about the age of the film.
8th day -	Ideas seemed to be grasped by both groups. They seemed to enjoy the demonstration on "solute", and "solvent".
9th day -	Two fifth grade girls had seen the ball and ring and the bimetallic rod demonstration on T.V. and were quite willing to share this information.
10th day -	A film "Learning About Heat" and a quiz were given.

11th day - In the demonstration about separating mixtures, salt was easier to separate from water than sugar. The sixth graders could come up with better definitions than the fifth.

12th day - Both classes showed interest.

13th day - Both classes seemed to want to have their notebooks complete and accurate.

14th day - Quiz.

15th day - Students have a good understanding of atomic size. They named a large number of materials that were not composed of one type of atom.

16th day - Most of the students finished the quiz in five minutes. The descriptions were fairly good in the lab work. Both classes discussed subatomic particles intelligently.

17th day - The quiz was finished in three to five minutes. The results were better than yesterday. The sixth graders did well. The fifth graders did not know how to round off numbers, so we spent some time on that.

18th day - Both classes enjoyed the film "A is for Atom".

19th day - Fifth graders had more trouble with isotopes than the sixth graders. Molecules of like atoms was understood in each class.

20th day - Most of the students showed interest and understanding in the composition and diagramming of molecules. Many were pleased to have the formulas for some familiar compounds given to them. They had trouble understanding the law of definite proportions.

21st day - Some of the students had trouble remembering the symbols for the elements. The interest in lab was not as high as it had been in the past.

22nd day - The concepts presented seemed more easily grasped than in the previous two lessons and interest was improved.

23rd day - The review went well.

24th day - Post Test.

CHAPTER II

REVIEW OF LITERATURE

Researchers involved in studying changes in elementary school science curricula have had several factors to consider. Scott (20:106) found that where science teaching was provided in the elementary school the program was generally prescribed by the children's textbooks. He disagreed greatly with this approach because he thought it did not show the true character of science and presented factual information in an authoritarian manner. Scott suggested:

> A science program which would encourage questions, which would promote reasoned guessing and the subjection of guesses to controlled tests, which would encourage individual discovery--this is more consistant with the nature of science than is the program concerned with social utility and technology.

White (27:520) thought that the lack of coordination among the various levels of education was a grave problem in education. He believed that the general objectives of science should provide a basis for a science background for all students. He also contended there was a necessity to challenge those pupils desiring further science work and to recognize and to encourage potential scientists.

Mallison (14:268) stated four major problems which remained unsolved in the improvement of elementary school science. They were (a) lack of direction, (b) lack of order, (c) lack of continuity, and (d) lack of adequately trained teachers. Mallison quoted from the Thirty-First Yearbook of the National Society for the Study of Education, Part I, in an article entitled "A Program for Teaching Science".

> Here for the first time, a committee of experts in science education stated that a continuous, sequential program of instruction should begin in the kindergarten and extend through grade twelve.

A number of writers have presented ideas regarding discovery teaching, inquiry, problem solving, and science curricula. Heathers (8:202) believed that the focus on process (Discovery teaching) discouraged three faults common to science teaching. They were:

> (1) teaching facts not put to use in solving scientific problems. (2) teaching technical facts rather than how scientific principles are put to work to serve practical ends. (3) Answering children's questions instead of teaching them to answer questions via the scientific method.

Bruner (4:Ch.II) also emphasizes in his studies the educational benefits derived from discovering concepts for oneself.

Stendler (23:35) discussed the need to plan activities for children which would make them think rather than simply find solutions to specific problems. Walbesser (26:296) described the American Association for the Advancement of Science (AAAS) Materials. The primary objective of these materials was to construct activities that would shape the behavior of pupils and which would reflect underlying processes of science. Michals (17:335) suggested that whenever possible one should include problem solving characteristics when teaching. Heffernan (9:32) stated emphatically that we should teach the scientific method and not a group of facts. Suchman (24:47) investigated inquiry training in the elementary school. He concluded that inquiry skills of fifth grade children can be improved. Fish and Saunders (6:22) would like to see a change from the usual specific subject matter application to the inquiry approach.

> The continued accrual of scientific knowledge is contingent upon the promotion of inquiry by the pupil where the excitement of problematic situation and hypothesis testing is the stimulus to devise other and often increasingly difficult problematic situations.

Atkin and Karplus (1:51) discussed discovery versus invention. They stated a positive regard for discovery teaching in that discovery appeared to be strongly motivating and rewarding. They thought that discovery teaching was reasonably efficient even when compared to an expository approach. However, Atkin and Karplus did indicate that many persons concerned with science teaching disagreed with discovery teaching because it was too time-consuming and in - efficient.

Even though Karplus emphasized discovery teaching, he described a study he was conducting in which science content is of utmost importance. (12:45)

The Science Curriculum Improvement Study is attempt-

> ing to develop a teaching program whose objective is the increase of scientific literacy in the school and adult population.
>
> The general strategy of the study is to confront the elementary school children with first hand experience of natural phenomena and with intellectual challenges that will stimulate their further cognitive development.
>
> The program will begin with children in kindergarten and first grade. Each year additional material will be made available to continue the program with the same group of children as they advance from grade to grade.
>
> In the current exploratory phase, work is also in progress to determine ways in which pupils' learning can be gauged. Since communication with young children for evaluation is not easy to accomplish in a standardized and reproducible fashion, novel approaches are called for and are being studied.

Methods of teaching science have been varied in scope. McAnarney (15:53-54) urged that teachers ought to emphasize laboratory procedures. He thought every science teacher should keep in mind the following points:

> (1) The experiment should precede rather than follow reading or discussion. (2) Use pupil-teacher planning. (3) Use both inductive and deductive processes. (4) Experiment should raise as many or more questions as it answers.

Hedges and McDougall (10:66) reported on teaching fourth grade science by means of programmed science materials with laboratory experiences. They concluded that fewer laboratory materials are needed because children worked at different rates. The students were quite interested and final achievement scores were in favor of the experimental group. Both teachers and pupils enjoyed the materials.

Barth (3:200-207) reported that it was possible to mold, manipulate and use failure as a powerful learning device. His study involved the presentation of an experiment to elementary children. After the demonstration the students wrote directions so that a person in another country (or room) could perform the same experiment. The directions were given to a child from another room to perform the experiment. Trouble was usually encountered and the class realized it was the fault of the inadequate directions. The instructor performed a second experiment and the same procedure was followed. The directions written by the students after the second experiment were more easily followed.

Hawkins (7:78) reported on the Elementary Science Activities Project. Their work has been directed to the improvement of elementary science by cooperative efforts between scientists and teachers.

Psychological factors related to science teaching also have been investigated. McCollum (16:240) studied the possibility that determining science maturity may be a means of improving the program in elementary science. His research indicated that the so-called science maturity is much broader than mental development as measured by intelligence tests. He did, however, find some positive correlation between the two.

Inbody (11:277) attempted to discover something of children's understanding of natural phenomena before they entered first grade. He concluded that children were able to understand cause and effect relationships. He believed that plans for science instruction should include consideration for the real not voiced understandings of the children and the way children think and reason.

Stendler (22:832-835) offered a possible explanation of how readiness for learning physics could be developed. She explored the hypothesis that particular childhood experiences structure an individual's perceptions of the physical world; that these perceptions are stored as information in cell-assemblies in the cortex; and that this facilitates the learning of the concepts in the physical sciences. Stendler said that we need teaching models that will help elementary school pupils develop the cognitive skills needed for the physical sciences.

CHAPTER III

PRESENTATION AND ANALYSIS OF DATA

Mercer Island Control Group. The control group (N 52) consisted of fifth and sixth grade pupils in the Island Park Elementary School. The pre test mean for the group was 3.37 with a standard deviation of 4.10. The post test mean was 4.86 with a standard deviation of 4.30. The standard deviation of the difference between means was 3.62 which gave a t value of 2.907 with 51 degrees of freedom. This is significant at the .01 level of confidence. Data regarding the pre and post test scores for students in this group have been placed in Appendix B and the analysis of these data has been given in Table VI.

Bellevue Community College Group. The Bellevue college group (N 28) took the same pre and post test as the experimental and control groups. The pre test mean of the community college group was 11.21 with a standard deviation of 4.93. The post test mean was 15.01 with a standard deviation of 4.50. The standard deviation of the difference between means was 3.45 which gave a t value of 5.8219 with 27 degrees of freedom. Data regarding the pre and post test scores for students in this group have been placed in Appendix C and in Table VII was a summary of the scores.

The physical Science Preparation of most students in

TABLE VI

ANALYSIS OF PRE AND POST TEST DATA FOR THE

MERCER ISLAND CONTROL GROUP

AVERAGE PRE TEST	3.37
AVERAGE POST TEST	4.86
AVERAGE DIFFERENCE	1.49
RANGE PRE TEST	-4.30 to 19.70
RANGE POST TEST	-3.00 to 18.30
SIGMA PRE TEST	4.10
SIGMA POST TEST	4.30
SIGMA DIFFERENCE	3.62

T 2.9709 WITH 51 DEGREES OF FREEDOM
Significant at .01 level of confidence

TABLE VII

ANALYSIS OF THE PRE AND POST TEST DATA OF THE

BELLEVUE COMMUNITY COLLEGE GROUP

AVERAGE PRE TEST	11.21
AVERAGE POST TEST	15.01
AVERAGE DIFFERENCE	3.79
RANGE PRE TEST	2.30 to 19.70
RANGE POST TEST	6.30 to 21.30
SIGMA PRE TEST	4.93
SIGMA POST TEST	4.50
SIGMA DIFFERENCE	3.45

T 5.8219 WITH 27 DEGREES OF FREEDOM
Significant at .01 level of confidence

this college group was determined from their transcripts. A summation of this information has been presented in Appendix D.

Mercer Island Experimental Group. The experimental group (N = 55) pre test mean was 3.37 with a standard deviation of 4.59. The post test mean was 11.67 with a standard deviation of 5.47. The standard deviation of the difference between means was 4.69 which gave a t value of 12.3873 with 54 degrees of freedom. In Appendix E data were given regarding pre and post test scores of this experimental group and in Table VIII the analysis of the scores was presented.

Ellensburg Control Group. The pre test mean for this control group (N = 55) was 2.23 with a standard deviation of 3.69. The post test mean was 2.48 with a standard deviation of 3.96. In Appendix F were placed the individual pre and post test scores. Although there was a slight difference between means, the difference was not significant based upon a t test analysis of the .05 level. Table IX provides an analysis of the pre and post test data for this control group.

Ellensburg College Group. The college class (N = 32) that took the same pre and post test as the experimental and control groups consisted of students at different years in college but who were enrolled in their first college chemistry course. Most of the students had completed high school chemistry and either high school physics or college physical science. Appendix G includes data regarding the preparation of the college group in the physical sciences.

The pre test mean of the college group was 11.54 with a standard deviation of 3.64. The post test mean was 16.95 with a standard deviation of 3.31. The standard deviation of the difference between means was 3.65 which gave a t value of 8.3876 with 31 degrees of freedom. This is very significant beyond the .01 level of confidence. Appendix H provides data regarding scores for the students in this group and Table X shows the analysis of the scores.

Ellensburg Experimental Group. The experimental group (N 41) pre test mean was 2.34 with a standard deviation of 3.39. The post test mean was 10.78 with a standard deviation of 5.21. The standard deviation of the difference between means was 5.01 which gave a t value of 10.77 with 40 degrees of freedom. Appendix I provides data regarding pre and post test scores of the experimental group and in Table XI is a summary of the analysis of the scores.

Comparison of Groups in the Mercer Island Study. The differences between the means of the pre and post test of the control group, the community college group and the experimental group were 1.49, 3.79, and 8.30 respectively. In comparing the average difference between pre and post test means of the experimental and control groups, the t value

TABLE VIII

ANALYSIS OF THE PRE AND POST TEST SCORES OF

THE MERCER ISLAND EXPERIMENTAL GROUP

AVERAGE PRE TEST	3.37
AVERAGE POST TEST	11.67
AVERAGE DIFFERENCE	8.30
RANGE PRE TEST	-4.30 to 21.00
RANGE POST TEST	-0.30 to 23.70
SIGMA PRE TEST	4.59
SIGMA POST TEST	5.47
SIGMA DIFFERENCE	4.96

T 12.3973 WITH 54 DEGREES OF FREEDOM
Significant at the .01 level of confidence

TABLE IX

ANALYSIS OF PRE AND POST TEST DATA FOR

THE ELLENSBURG CONTROL GROUP

AVERAGE PRE TEST	2.23
AVERAGE POST TEST	2.48
AVERAGE DIFFERENCE	.25
RANGE PRE TEST	-5.7 to 10.3
RANGE POST TEST	-4.00 to 14.3
SIGMA PRE TEST	3.69
SIGMA POST TEST	3.96
SIGMA DIFFERENCE	4.07

T .4632 WITH 54 DEGREES OF FREEDOM
Not significant at .05 level of confidence

TABLE X

ANALYSIS OF PRE AND POST TEST DATA OF

THE ELLENSBURG COLLEGE GROUP

AVERAGE PRE TEST	11.54
AVERAGE POST TEST	16.95
AVERAGE DIFFERENCE	5.41
RANGE PRE TEST	5.0 to 17.0
RANGE POST TEST	9.0 to 22.3
SIGMA PRE TEST	3.64
SIGMA POST TEST	3.31
SIGMA DIFFERENCE	3.65

T 8.3876 WITH 31 DEGREES OF FREEDOM
Significant at .01 level of confidence

TABLE XI

ANALYSIS OF PRE AND POST TEST SCORES OF

THE ELLENSBURG EXPERIMENTAL GROUP

AVERAGE PRE TEST	2.34
AVERAGE POST TEST	10.78
AVERAGE DIFFERENCE	8.44
RANGE PRE TEST	-3.0 to 13.0
RANGE POST TEST	-4.3 to 22.3
SIGMA PRE TEST	3.39
SIGMA POST TEST	5.21
SIGMA DIFFERENCE	5.01

T 10.77 WITH 40 DEGREES OF FREEDOM
Significant at .01 level of confidence

was 8.0593 with 5 degrees of freedom. This is significant beyond the .01 level of confidence.

An inference or conclusion will not be made from the test results of the community college group. The average difference between the pre and post test means of the experimental and community college groups gave a t value of 4.2918 with 81 degrees of freedom which is significant at the .01 level of confidence. In Table XII were comparisons of the Mercer Island Study groups.

<u>Comparison of Groups in the Ellensburg Study</u>. The differences between the means on the pre and post test of the control group, the college group and the experimental group were .25, 5.41, and 8.41 respectively. In comparing the average differences between pre and post test means of the control and experimental groups, the t value was 8.8175 with 94 degrees of freedom which is very significant at the .01 level of confidence. The average differences between the pre and post test means of the college group and the experimental group gave a t value of 2.8725. This value is significant at the .01 level of confidence. Table XIII provided comparisons of the Ellensburg Study groups.

<u>Comparison of the Two Experimental Groups</u>. A t test was applied to the difference between the means of the pre and post test scores of the two experimental groups. This value was 0.1397 which was not significant at the .05 level

of confidence. Comparisons of the two experimental groups were in Table XIV.

Comparison Between the Mercer Island Experimental Group and the Ellensburg College Group. A comparison between the experimental group on Mercer Island and the college group in Ellensburg gave a t value of 2.8651. This value was significant at the .01 level of confidence. Table XV showed a comparison between these two groups.

Comparison of the Two College Groups. When difference of means of the two college groups were compared the t value was 1.7548. This value was not significant at the .05 level of confidence. Table XVI provided a comparison of these two groups.

TABLE XII

COMPARISONS OF MEANS FOR THE MERCER ISLAND CONTROL, EXPERIMENTAL, AND COLLEGE GROUPS

	Number	Pre test mean	Post test mean	Difference	T Value
Control group	52	3.37	4.86	1.49	
					8.0593
Experimental group	55	3.37	11.67	8.30	
					4.2918
Community College group	28	11.21	15.01	3.79	

Both T values significant at .01 level of confidence.

TABLE XIII

COMPARISONS OF MEANS FOR THE ELLENSBURG CONTROL, EXPERIMENTAL, AND COLLEGE GROUPS

	Number	Pre text mean	Post test mean	Difference	T Value
Control group	55	2.23	2.48	.25	
					8.8175
Experimental group	41	2.34	10.78	8.44	
					2.875
Ellensburg College group	32	11.54	16.95	5.41	

Both T values significant at .01 level of confidence.

TABLE XIV

COMPARISON OF MEANS FOR MERCER ISLAND AND

ELLENSBURG EXPERIMENTAL GROUPS

	Number	Pre test mean	Post test mean	Differ- ence	T Value
Mercer Island experimental group	55	3.37	11.67	8.30	
					0.1397
Ellensburg experimental group	41	2.34	10.78	8.44	

T value is not significant at .05 level of confidence.

TABLE XV

COMPARISON OF MEANS OF MERCER ISLAND EXPERIMENTAL GROUP

WITH ELLENSBURG COLLEGE GROUP

	Number	Pre test mean	post test mean	Differ-ence	T Value
Mercer Island experimental group	55	3.37	11.67	8.30	
					2.8651
Ellensburg College group	32	11.54	16.95	5.41	

T value is significant at .01 level of confidence.

TABLE XVI

COMPARISON OF MEANS FOR MERCER ISLAND COLLEGE

GROUP WITH ELLENSBURG COLLEGE GROUP

	Number	Pre test mean	Post test mean	Difference	T Value
Mercer Island College group	28	11.21	15.01	3.79	
					1.7548
Ellensburg College group	32	11.54	16.95	5.41	

T value is not significant at the .05 level of confidence.

CHAPTER IV

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

I. SUMMARY

This study involved the understanding and reactions of fifth and sixth grade pupils in Mercer Island, Washington to selected principles commonly taught in beginning college chemistry. An earlier study conducted at Ellensburg, Washington was used as a basis for the design and for comparison. The modifications to the Ellensburg Study were:

a. Pupils on Mercer Island were not attending a campus school.

b. The college chemistry students who were tested were attending a community college rather than a four-year college.

c. The instructor had not taught the fifth and sixth grade classes prior to the study.

d. The instructor did see the pre - post test prior to teaching the chemistry unit.

e. An attitude scale was developed and eventually used.

The scores on the pre and post test were analyzed by computer and comparisons between the groups were made. The test questions were analyzed to show the number of times certain aspects of chemistry were touched upon in the test. The test was also analyzed to determine the level of learning tested by each item. Pupil reactions were recorded to provide some basis for comment regarding pupil interest and the advisability of spending prolonged periods on specific areas of science in the elementary school.

II. CONCLUSIONS

1. The pre and post apparently was a satisfactory instrument to ascertain the increase in comprehension of selected principles of chemistry by elementary pupils.
2. Fifth and sixth grade children can learn certain concepts of chemistry.
3. There was no apparent difference between the Mercer Island and Ellensburg fifth and sixth grade experimental pupils.
4. There were no apparent differences between the Bellevue Community college and Ellensburg college groups.
5. There was no difference in attitude toward science between the Mercer Island experimental and control groups.
6. Laboratory experiences were effective in teaching chemistry to elementary pupils.
7. Elementary children were interested in studying chemistry.
8. College students who had completed high school chemistry

showed limited retention of basic concepts.

9. Many teachers of intermediate grade pupils could teach a similar unit if they were given some preliminary instruction.

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APPENDIX A

ANALYSIS OF TEST FOR EMPHASIS OF CHEMISTRY ASPECTS

Term, Concept, Etc.	Items in Which Term Used or Suggested
Atom	1, 2, 7, 9, 16, 17
Atomic Nucleus	1, 9, 19
Atomic Weight	1, 23, 24
Boiling	20, 25
Burning	15, 18, 20
Carbon	23
Chemical Combination or Reaction	3, 4, 6, 7, 8, 11, 15, 17, 18, 20, 21
Chemical Properties	2
Compound	7, 16
Condensation	21, 25
Conservation of Matter	3, 4, 15
Contraction	12
Dissolving	10, 11, 13
Electron	1, 9, 19, 24
Element	1, 2, 14, 16
Endothermic	18
Evaporating	20, 21, 25
Evaporation	10
Exothermic	18
Expansion	5, 12
Gas	4, 15, 18, 20, 22
Heat Gained	3
Heat Lost	3
Iron	4
Iron Sulfide	4
Isotope	23, 24
Liquid	20
Magnetism	10
Matter	5, 19, 22
Melting	20
Mixture	10, 11, 13, 16, 22
Molecule	2, 12, 16, 17
Neutron	1, 9, 19, 23, 24
Oxygen	15
Physical Combination or Change	7, 10, 11, 17, 21, 25
Precipitate	6
Proton	1, 9, 19, 23, 24
Silver Nitrate	6
Sodium Chloride	6

Term, Concept, Etc.	Items in Which Term Used or Suggested
Solid	20, 22
Soluble	6
Solute	3, 11, 13
Solution	3, 13
Solvent	3, 11, 13
Substance	1, 6, 10
Sulfur	4
Sulfuric Acid	8
Uranium	24

APPENDIX B

PRE AND POST TEST SCORES OF THE MERCER ISLAND CONTROL GROUP

Student Number	Pre Test	Post Test	Difference
1	2.30	2.30	0.00
2	3.70	2.30	-1.40
3	6.30	10.30	4.00
4	-4.30	2.30	6.60
5	-1.70	1.00	2.70
6	0.00	4.00	4.00
7	8.00	2.70	-5.30
8	-1.00	-0.30	0.70
9	5.00	5.00	0.00
10	-0.30	-3.00	-2.70
11	0.00	1.00	1.00
12	7.30	7.70	0.40
13	-1.70	2.30	4.00
14	3.70	-1.70	-5.40
15	2.30	2.30	0.00
16	4.00	-0.30	-4.30
17	-3.00	9.00	12.00
18	4.30	1.70	2.60
19	7.70	14.30	6.60
20	7.00	6.30	-0.70
21	2.30	1.00	-1.30
22	-0.30	6.70	7.00
23	6.70	3.70	-5.35
24	3.00	4.70	1.70
25	4.70	6.70	2.00
26	2.00	5.70	3.70
27	2.30	3.70	1.40
28	5.00	5.00	0.00
29	1.00	6.30	5.30
30	4.00	9.00	5.00
31	6.30	9.00	2.70
32	0.30	-1.30	-1.60
33	19.70	18.30	-1.40
34	6.30	7.70	1.40
35	2.30	-0.30	-2.60
36	-1.70	-1.70	0.00
37	7.70	7.70	0.00
38	1.00	4.00	3.00
39	6.30	6.30	0.00
40	2.30	8.70	6.40

Student Number	Pre Test	Post Test	Difference
41	5.00	11.70	6.70
42	2.30	2.30	0.00
43	2.30	2.30	0.00
44	7.70	8.00	0.30
45	6.30	7.70	1.40
46	9.00	10.30	1.30
47	-3.00	1.00	4.00
48	3.70	1.00	-2.70
49	5.00	5.00	0.00
50	7.70	11.00	3.30
51	-3.70	6.30	10.00
52	2.30	6.30	4.00

APPENDIX C

PRE AND POST TEST SCORES OF THE BELLEVUE COMMUNITY COLLEGE GROUP

Student Number	Pre Test	Post Test	Difference
1	18.30	19.70	1.40
2	11.00	14.30	3.30
3	3.70	14.30	10.60
4	9.00	10.30	1.30
5	11.70	11.70	0.00
6	5.00	11.70	6.70
7	9.00	10.30	1.30
8	2.30	7.70	5.40
9	15.70	21.00	5.30
10	10.30	17.00	6.70
11	10.30	21.30	11.00
12	6.30	14.30	8.00
13	14.30	15.70	1.40
14	13.00	14.30	1.30
15	9.30	14.30	5.00
16	10.30	11.70	1.40
17	6.30	11.70	5.40
18	19.70	15.70	-4.00
19	17.00	21.00	4.00
20	2.30	6.30	4.00
21	14.30	21.00	6.70
22	5.00	7.70	2.70
23	15.70	18.30	2.60
24	14.30	11.70	-2.60
25	18.30	19.70	1.40
26	14.30	21.00	6.70
27	14.30	18.30	4.00
28	13.00	18.30	5.30

APPENDIX D

PREPARATION IN THE PHYSICAL SCIENCES OF THE

BELLEVUE COMMUNITY COLLEGE GROUP

Student Number	High School Physics	High School Chem.	High School Phy. Sci.	College Physics	College Physical Science
1	x	x			
2					
3	x	x			
4			x		
5	x	x			
6		x			
7					
8		x			
9 (No Info)					
10					
11		x			
12		x			
13		x			
14					
15 (No Info)					
16	x				
17	x	x			
18	x	x	x		
19		x			
20 (No Info)					
21		x	x		
22					
23	x	x			
24					
25	x	x			
26					
27		x			
28		x	x		

APPENDIX E

PRE AND POST TEST SCORES OF THE

MERCER ISLAND EXPERIMENTAL GROUP

Student number	Pre Test	Post Test	Difference
1	1.00	5.00	4.00
2	-1.70	7.70	9.40
3	1.30	9.00	7.70
4	10.30	18.30	8.00
5	3.70	19.70	16.00
6	3.30	8.30	5.00
7	-0.30	3.70	4.00
8	-0.30	1.00	1.30
9	3.70	9.00	5.30
10	-1.70	13.00	14.70
11	5.00	5.00	0.00
12	-0.30	8.00	8.30
13	1.00	9.00	8.00
14	5.00	18.30	13.30
15	-0.30	7.70	8.00
16	7.70	14.30	6.60
17	-4.30	11.70	16.00
18	-0.30	3.70	4.00
19	3.70	6.30	2.60
20	8.70	11.70	3.00
21	-1.70	14.30	16.00
22	2.70	9.00	6.30
23	1.00	9.00	8.00
24	6.00	19.70	13.70
25	4.00	13.00	9.00
26	5.00	13.00	8.00
27	6.30	9.00	2.70
28	12.00	11.70	-0.30
29	-0.30	9.00	9.30
30	7.70	13.00	5.30
31	3.70	13.00	9.30
32	3.70	10.30	6.60
33	2.30	14.30	12.00
34	3.70	11.70	8.00
35	7.70	11.70	4.00
36	-2.00	13.00	15.00
37	9.00	18.30	9.30

Student Number	Pre Test	Post Test	Difference
38	1.00	15.70	14.70
39	6.30	15.70	9.40
40	6.30	19.70	13.40
41	21.00	23.70	2.70
42	5.00	22.30	17.30
43	-0.30	14.30	14.60
44	5.00	18.30	13.30
45	1.00	17.30	16.30
46	-0.30	15.70	16.00
47	7.70	18.30	10.60
48	13.00	17.00	4.00
49	-3.00	3.70	6.70
50	-3.00	7.70	10.70
51	1.00	2.30	1.30
52	6.30	9.00	2.70
53	3.30	8.00	4.70
54	-1.70	10.30	12.00
55	1.00	-0.30	-1.30

APPENDIX F

PRE AND POST TEST SCORES OF THE

ELLENSBURG CONTROL GROUP

Student Number	Pre Test	Post Test	Difference
1	10.30	11.70	1.40
2	2.70	-1.70	-4.40
3	-4.30	-4.00	.30
4	-5.70	-4.30	1.40
5	- .30	-2.30	-2.00
6	4.00	-1.70	-5.70
7	5.30	2.30	-3.00
8	5.00	5.70	.70
9	1.00	2.30	1.30
10	5.70	5.00	- .70
11	1.00	2.30	1.30
12	3.70	5.00	1.30
13	2.30	6.30	4.00
14	1.00	9.00	8.00
15	9.00	3.70	-5.30
16	7.30	9.00	1.70
17	1.00	3.70	2.70
18	1.30	- .30	-1.60
19	-1.70	3.70	5.40
20	- .30	1.00	1.30
21	- .30	6.30	6.60
22	-1.00	3.00	4.00
23	4.00	5.00	1.00
24	-3.00	- .30	2.70
25	6.30	6.30	.00
26	-1.30	- .30	1.00
27	-2.30	7.70	10.00
28	2.30	1.00	-1.30
29	5.00	- .30	-5.30
30	7.70	14.30	6.60
31	5.00	-1.00	-6.00
32	1.00	- .30	-1.30
33	.00	-1.30	-1.30
34	- .30	-3.00	-2.70
35	3.70	1.30	-2.40
36	10.30	6.30	-4.00
37	3.00	- .30	-3.30

Student Number	Pre Test	Post Test	Difference
38	-4.30	2.30	6.60
39	2.30	1.00	-1.30
40	5.00	-1.70	-6.70
41	3.70	1.00	-2.70
42	2.30	2.30	.00
43	5.00	-3.00	-8.00
44	2.30	6.30	4.00
45	2.30	3.70	1.40
46	5.00	- .30	-5.30
47	2.30	3.70	1.40
48	2.30	2.30	.00
49	3.70	6.30	2.60
50	1.00	-3.70	-4.70
51	-5.30	3.70	9.00
52	-3.00	-1.70	1.30
53	7.70	6.30	-1.40
54	3.70	3.70	.00
55	-1.70	3.70	5.40

APPENDIX G

PREPARATION IN THE PHYSICAL SCIENCES

OF THE ELLENSBURG COLLEGE GROUP

Student Number	High School Physics	High School Chem.	High School Phy. Sci.	College Physics	College Physical Science
1		x			x
2		x			x
3					x
4	x				
5		x			x
6		x			x
7	x	x			
8	x	x		x	
9	x	x	x		
10		x			
11		x			
12		x	x		x
13	x	x	x		
14		x	x		
15	x			x	x
16	x			x	
17	x	x			
18		x			
19	x	x			
20		x			x
21		x			
22	x	x			
23		x			
24	x	x	x		
25	x	x			
26	x	x			x
27					x
28	x	x		x	
29	x	x			x
30	x	x	x		x
31					
32		x			

APPENDIX H

PRE AND POST TEST SCORES OF THE

ELLENSBURG COLLEGE GROUP

Student Number	Pre	Post	Diff
1	10.30	18.30	8.00
2	15.70	19.70	4.00
3	10.30	14.30	4.00
4	5.00	13.00	8.00
5	10.30	19.70	9.40
6	10.30	14.30	4.00
7	10.30	9.00	-1.30
8	11.70	19.70	8.00
9	17.00	19.70	2.70
10	11.70	17.00	5.30
11	13.00	21.00	8.00
12	6.30	13.00	6.70
13	11.70	21.00	9.30
14	14.30	22.30	8.00
15	9.00	15.70	6.70
16	7.70	13.00	5.30
17	11.70	17.00	5.30
18	10.30	14.30	4.00
19	7.70	14.30	6.60
20	11.70	17.00	5.30
21	13.00	17.00	4.00
22	17.00	22.30	5.30
23	17.00	18.30	1.30
24	17.00	18.30	1.30
25	7.70	15.70	8.00
26	13.00	10.30	-2.70
27	13.00	18.30	5.30
28	5.00	21.00	16.00
29	15.70	19.70	4.00
30	14.30	15.70	1.40
31	5.00	15.70	10.70
32	15.70	17.00	1.30

APPENDIX I

PRE AND POST TEST SCORES OF THE

ELLENSBURG EXPERIMENTAL GROUP

Student Number	Pre Test	Post Test	Difference
1	3.70	18.30	14.60
2	-1.30	7.70	9.00
3	6.30	9.00	2.70
4	3.70	10.30	6.60
5	1.00	-4.3-	-5.30
6	6.70	19.70	13.00
7	1.00	18.70	17.70
8	6.30	17.00	10.70
9	13.00	18.30	5.30
10	1.70	8.00	6.30
11	2.30	15.70	13.40
12	- .70	5.00	5.70
13	3.00	11.70	8.70
14	10.30	14.30	4.00
15	- .30	8.30	8.60
16	3.70	9.00	5.30
17	1.00	7.70	6.70
18	.00	13.00	13.00
19	.00	9.00	9.00
20	.00	13.00	13.00
21	1.70	10.70	9.00
22	.00	-5.30	5.30
23	2.30	10.30	8.00
24	- .30	11.70	12.00
25	4.30	10.30	6.00
26	-3.00	6.30	9.30
27	2.30	13.00	10.70
28	10.30	16.00	5.70
29	-3.00	9.00	12.00
30	1.00	11.70	10.70
31	1.00	15.70	14.70
32	1.00	-6.30	5.30
33	3.70	14.30	10.60
34	1.00	7.70	6.70
35	- .70	7.70	8.40
36	1.00	10.30	9.30
37	1.00	22.30	21.30

Student Number	Pre Test	Post Test	Difference
38	2.70	9.00	6.30
39	5.00	- .30	-5.30
40	- .30	9.30	9.60
41	3.70	6.30	2.60

APPENDIX J

THE TEACHING UNIT

CONTENT	LEARNING EXPERIENCES	MATERIALS
Introduction and overview.	Discuss the general nature of the unit. Use some pictures to illustrate some of the areas to be covered such as atoms. Point out that some of the material may be repetitious but is now being taught in a sequence. Give pre-test with explanation that this is to determine their progress.	pictures por-test
Chemistry is the study of what matter is made of, what are the properties of the matter and the changes that occur to matter.	Use board and have pupils give items which they think are not matter and those which they think are matter. Discuss these. Non-matter includes ideas, beliefs, feelings, words, noise, faith, light, heat.	
Matter is anything which takes up space and has weight.	Demonstration and discussion of matter occupying space and having weight. Use balance and try to weigh a word such as rock and then weigh the rock. The idea or word is not matter but the rock is. Use other illustrations if necessary.	weights balance rock jar water pan
	Demonstration and discussion of occupying space. Fill a jar with water and then place a rock in the jar. The rock and water both take up space. Air	

CONTENT	LEARNING EXPERIENCES	MATERIALS
	in a jar occupies space. Illustrate this with a jar of air placed upside down in a pan of water. Put the definition of matter on the board.	
	Demonstration and discussion that air occupies space in a balloon. Fill balloon with air and place in a pan of water.	balloon
	Demonstration and discussion that air occupies space and has weight in a ball. Weigh an empty playground ball, fill with air and reweigh. Ask students to explain difference in weight.	playground ball
Different types of matter have different properties or characteristics such as weight, shape, color, size, taste, odor, stable or unstable in shape. There are three forms of matter. A solid is a form of matter which keeps a definite shape. A liquid form of matter is one which takes the shape of the container in which it is placed but does not necessarily fill the container. A gas is a form of matter which	Introduce a short lab session. Pupils are to examine solids, liquids, and gasses of various types and to describe them in their own words. Caution them about tasting or have certain numbered items marked with <u>do not taste</u>. After this has been completed, have children help list on the board the ways they used to describe the types of matter. Then try and have the pupils list all the types of matter which have one thing in common such as having a definite shape and not having a definite shape. Then try and separate out those items not having a definite shape into those which stay in a container and those which do not. There will be some difficulty in doing this and	alcohol water wood rock coal ammonia dry ice iodine oil butter syrup rubber stopper gasoline

CONTENT	LEARNING EXPERIENCES	MATERIALS
takes the shape of the container in which it is placed and fills the container.	the pupils will have to be led in their thinking.	
Sometimes solids may have the characteristics of a luquid, and a gas may have characteristics of a liquid.	Illustrate with containers of sand, flour and sugar which take the shape of the container.	beakers flour sand sugar
	Use a container of CO_2 gas (dry ice) which will tend to stay in the container for the demonstration.	mason jar cap dry ice
	Write definitions for solid, liquid and gas on the board using student suggestions.	
	Give a short quiz on the types of matter and their characteristics.	quiz
Matter can be changed from one form to another in several ways.	Presentation and discussion of demonstrations.	ice butter warm gelatin pan burner tripod gauze spoon benzaldehyde or perfume
A solid can be changed to a liquid by heating.	1. Heat ice and butter	
A liquid can be changed to a solid by colling.	2. Cool warm gelatin, cool liquid butter.	
A liquid can be changed to a gas by heating.	3. Boil water and condense using a cold pan above the water--emphasize water vapor and not steam.	
A gas can be changed to	4. Place benzaldehyde or cheap per-	

CONTENT	LEARNING EXPERIENCES	MATERIALS
a liquid by cooling.	fume in open container on desk--have children detect odor. Discuss cooking odors, melting snow, gas in car from liquid to vapor.	
	Observe and discuss film.	SOLIDS, LIQUIDS, GASES projector and screen
Particles of matter in a solid can be separated from each other by dissolving. The matter which is dissolved is called the solute and the matter in which the solute is dissolved is called the solvent. Different solutes will dissolve in different solvents. The solute is always the lesser amount.	Demonstration and discussion of terms solute and solvent. Illustrate these and the ability to dissolve or not with oil and water, water and sugar or salt, alcohol and sugar, alcohol and some organic compound, chloroform and butter.	butter sugar beakers water oil chloroform alcohol salt or sugar
The amount of space occupied by matter can be changed by adding heat energy or removing heat energy. Usually the more heat which is supplied, the more space taken up by the matter and usually	Observation and discussion of the following demonstrations. 1. Heating and cooling of ring and ball. 2. Heating of closed flask with	ring ball burner tripod gauze balloon

CONTENT	LEARNING EXPERIENCES	MATERIALS
the more heat energy removed, the less space taken up by the matter.	tube and observing water rise. Cooling effect of same. 3. Heating of thermometer. Cooling effect of same. 4. Heating of the flask covered with a balloon to watch exoansion of air. Cooling effect of same.	several erlenmeyers rubber stopper ice beakers thermometer food coloring for water glass tubing bimetallic rod
Two different forms of matter which are heated the same amount do not always expand the same amount.	5. Heat bimetallic rod and cool same.	
The changes in form or size of matter are called physical changes because the kind of matter at the end of the change is the same kind of matter as before the change.	Discuss water becoming ice and the fact that this is an exception and an expansion occurs which results in ice being lighter and thus floating. Discuss forming water from ice and the condensing of the water when the ice melts and thus becomes heavier.	
	Observation and discussion of film.	LEARNING ABOUT HEAT
	Rediscuss physical changes and put definition on board. Discuss other types of physical changes.	Projector and screen
	Short quiz and review discussion.	quiz
Different kinds of matter can be mixed as in the case	Discuss mixtures and have pupils give a number of examples of mixtures	milk sugar

CONTENT	LEARNING EXPERIENCES	MATERIALS
of dissolving a solute in a solvent. When mixtures of matter are made, it is often possible to separate the types of matter in the mixture by physical means.	such as cocoa and milk, sugar and water, mud and water, etc.	water beakers iron filings sulfur CS magnet
Some common ways of separating mixtures are by evaporating, using magnetism and dissolving.	Prepare and have pupils observe these mixtures: iron filings and powdered sulfur; sugar and water; food coloring and water. Separate these--use a magnet to separate partially the iron from the sulfur, use CS to dissolve sulfur from the iron and sulfur mixture, boil off the water from sugar and water mixture, and boil and condense water from water and food coloring mixture. Separate sugar and sand by dissolving sugar in water. Discuss the new terminology and repeat the idea of physical change and physical separation.	burner erlenmeyer flask rubber stopper - 1 hole glass tubing food coloring tripod gauze
The amount of matter produced when making a mixture is equal to the total amount of matter used in making the mixture. Matter cannot be created or destroyed by mixing.	Weigh sugar and beaker of water, mix and weigh again. Do the same with iron and sulfur.	sugar beaker water scales and weights iron sulfur
Matter by weight cannot be created or destroyed by chemical means. Even though	Discuss the idea of a chemical change and producing something different from what you began with. Compare this to	

CONTENT	LEARNING EXPERIENCES	MATERIALS
a new type of matter is produced, it weighs the same as the total weights of the kinds of matter used in making the new material.	adding sugar and water, which even though the sugar disappeared in the water, the end result was still sugar and water.	
We can change matter by burning, by causing two materials to unite, or by causing materials to change about in some way.	Pupils observe and discuss carefully the burning of paper or wood. What was left was ashes, smoke, and a gas which could not be seen. The combined weights would equal the weight of the wood plus the weight of the oxygen added. Illustrate by adding concentrated H_2SO_4 by weight to sugar in a closed container--use only a small amount of acid. Note the change. Weigh the sugar and beaker before, and weigh the sugar, beaker, and acid after. It may possibly weigh slightly less since some gas may be lost. Be certain to use small amounts of sugar and acid in a large, corked, erlenmeyer flask.	sugar H_2SO_4 - concentrated balance wood or paper matches pan silver nitrate solution sodium chloride solution
	Add silver nitrate to sodium chloride (solutions) and note the percipitation. Weigh each of the solutions before and the total product afterward.	large erlenmeyer flask cork
	Good review of physical and chemical change and all previous concepts.	
	Thorough quiz over first part of unit.	quiz

CONTENT	LEARNING EXPERIENCES	MATERIALS
All matter is made up of small particles called atoms.	Thorough discussion of at ms, smallness of size. Have pupils try to imagine the smallest thing they have seen--a grain of sand, dust particle, microscopic organisms--and emphasize that these small things are many times larger than at atom.	
When matter is made up of only one kind of atom it is called an element.		
There are many different types of elements, each with different properties.	Have the pupils list all the things which they think are elements. The teacher will separate out those which are not and explain that these contain more than one type of atom so cannot be called an element.	
92 natural elements have been found. Man has made some others.		
Each element has a chemical abbreviation or symbol. Some common symbols you should know are for these elements:	Bring in a periodic chart so pupils can see the num-periodic chart number of elements and their symbols.	ditto list of elements and symbols
H---hydrogen O---oxygen Au--gold Ag--silver C---carbon N---nitrogen	Use board and pupils taking notes or a guide sheet so pupils will become familiar with some of the chemical symbols. Give short quiz several times on sy bols for reinforcement.	carbon zinc copper tin nickel magnesium

CONTENT	LEARNING EXPERIENCES	MATERIALS
Al--aluminum Cu--copper Ni--nickel Fe--iron S---sulfur Sn--tin Cl--chlorine Na--soduim U---uranium Pu--plutonium Ra--radium	Have a short lab in which a number of elements are placed for the pupils to examine and to describe. Use carbon, zinc, copper, tin, aluminum, magnesium, nickle, sulfur, chromium, others.	sulfur chromium aluminum
The atoms of each element are made up of small subatomic particles. All atoms have these particles.	Discuss the meaning of subatomic.	
The three subatomic particles which seem most important to chemistry are the proton, neutron and electron.	Try to develop again the concept of small sizes of the atom and thus the very small size of the particles.	periodic chart
The atom is often pictured with a central heavy part called the nucleus. In the nucleus are located the protons and neutrons.	Sketch and discuss the nucleus of the atom showing protons and neutrons. Do not be concerned with charges although some pupil may bring this up.	
The proton and neutron weigh about the same. The electron weighs only about	Discuss differences in weight and relate the difference between electron weight and proton possibly using one pound and	ounce weight or something

CONTENT	LEARNING EXPERIENCES	MATERIALS
1/2000 as much as a proton.	one ton or possibly using one ounce with two pupils equal in weight to about 125 pounds.	similar
The number of protons in the nucleus of an atom of a particular element is always the same. This number of protons is the atomic number of the element.	Discuss atomic number and illustrate with several of the elements which pupils know. Use the periodic chart to locate atomic number and then relate this number to the number of protons.	periodic chart
In the atom of hydrogen there is one proton, in carbon there are six, in oxygen there are eight, etc.		
In lighter elements the number of neutrons is often about equal to the number of protons. Since electrons weigh so little, tha atomic weight of an atom is about equal to the number of protons and neutrons combined. The number of neutrons can be determined by subtracting the atomic number from the atomic weight.	Sketch nuclei of different elements to show the number of protons and neutrons. Use oxygen 16, carbon 12, hydrogen 1, and others.	
The electrons are pictured as located near the nucleus some distance away. They seem to form a cloud. The number of electrons is equal	Have students work in small groups and make sketches--large ones--of atomic structures. Use plastic materials and other substances to show nuclear arrangement.	plastic materials clay, etc.

CONTENT	LEARNING EXPERIENCES	MATERIALS
to the number of protons. The more electrons there are, the farther away from the nucleus are the outer ones.	Use ditto of structure with various seeds to have pupils represent electrons, protons, neutrons.	
One atomic mass unit equals a proton.	Have pupils calculate the atomic weights of different elements depending upon the number of protons, neutrons, and electrons. Calculate number of neutrons from atomic weight and number.	dittoed sheets various colored seeds
The atoms of some elements are very heavy because they have so many more neutrons than protons. For example, uranium, which is element 92 and therefore has 92 protons, may have an atomic weight of 234, 235, 238. This means that an atom of uranium might have 142, 143, or 146 neutrons. Such atoms are often unstable and may split and give off energy. An atom of uranium will have 92 electrons.	Short quiz on this section.	quiz
	Discuss uranium and possibly its use.	
	Diagram or have the pupils diagram the uranium atom with appropriate symbols--N for neutron, P for proton, and E for electron. Also, if time permits, have pupils diagram the atomic structure of other heavy atoms such as lead.	periodic chart
	Possibly discuss the splitting of the atom and the release of the energy holding the atom together.	large chart with diagram
The atom of an element always has the same number of protons but the number of neutrons may change. For example, carbon always has six protons but may have 5, 6, 7, 8, or 9	Discuss and sketch configurations including electrons of the various isotopes of carbon, oxygen, helium, hydrogen (2 and 3) and others.	
	Have pupils compute the number of protons and neutrons in isotopes of other	periodic charts

CONTENT	LEARNING EXPERIENCES	MATERIALS
neutrons. Therefore it is possible to have carbon 11, 12, 13, 14, 15. The same is true for oxygen. The most common form of oxygen is oxygen 16 which means that there are 8 protons and 8 neutrons. However, oxygen 17 and 18 are part of the atmosphere. These various forms of atoms of the element are known as isotopes of the element.	elemts--use the atomic weights from the periodic chart.	
Atoms of the same element often combine. When like atoms combine, a molecule of the element is formed. For example, two atoms of oxygen combine to form a molecule of oxygen, or O_2. This is the form in which oxygen is found in the air. Atoms of other elements can combine to form molecules also.	Discuss the idea of molecules of elements. Use several pieces of like materials--pencils, apples, beans, gumdrops, oranges--and fasten them together in some manner. Point out that now there are two atoms but they are the same so we now have a molecule of like atoms--therefore a molecule of an element. Have students diagram molecules of oxygen, hydrogen, chlorine, bromine. (O_2, H_2, Cl_2,Br_2)	apples oranges beans pencils rubber bands glue sticks
When atoms of different elements combine, the result is known as a compound. Some compounds are made up of only two different atoms.	Discuss and use sketches on the board to show compounds. Use compounds which have only two unlike atoms such as CO, CO_2, H_2O, NaCl, NH_3. Have pupils make simple sketches showing the atomic structure of the atoms com-	vinegar table sugar

CONTENT	LEARNING EXPERIENCES	MATERIALS
	posing molecules of the compounds indicated above.	sulfuric acid
	Discuss more complex compounds with which they are familiar. Vinegar, CH COOH; and table sugar. $C_{12}H_{22}O_{11}$; and sulfuric acid in car batteries H_2SO_4. Display and label.	
The atoms which form a particular compound always occur in the same amount or number. For example, water always has two hydrogen and one oxygen atoms. If these are not present, then water is not present. Carbon dioxide always has two atoms of oxygen and one of carbon.	Discuss and use other illustrations including those above.	
This rule that to form a particular compound the atoms must always be present in a certain number for each type of compound is known as the law of definite proportions.	Discuss amount or proportion. Use other compounds as an example. To form H_2SO_4 there always must be seven atoms with two being hydrogen, four being oxygen and one sulfur.	
	Quiz over work from the mid unit test.	quiz
Since atoms and molecules of elements and compounds are composed of protons, neutrons, and electrons and	Rediscuss matter and the fact that the pupils have been studying matter in more detail. Emphasize that matter is a general term like substance and elements,	

CONTENT	LEARNING EXPERIENCES	MATERIALS
these take up space and have weight, the atoms and molecules are building blocks of matter.	atoms, electrons, protons, molecules are simply particular building blocks of matter.	
Different compounds have different properties. These properties help man to do certain things. The properties which were discussed with regard to matter in general apply to compounds. For example, some compounds have certain tastes and can provide energy to the body. Other compounds can provide fuel. Some can be used to produce other compounds.	Discuss and use actual compounds for illustration of the properties. Review certain properties. Have a short lab and let the pupils describe compounds again using different ones. Caution regarding tasting and protect pupils from hazardous materials. Discuss and show solvents again. Discuss fuels again and use examples or samples.	salt sugar protein water gas alcohol coal paper or wood HCl zinc conc. H_2SO_4 HgO wood splint
To form a compound from various atoms or to make one compound from another is called a chemical change just as the term was used earlier. All chemical changes require that energy either be used or given off for the change to take place.	Show changing material to produce other materials. Burn paper or wood leaving charcoal, ashes, gas. Use acid on zinc and produce hydrogen--let it pop. Heat mercuric oxide and produce oxygen. Test. Note color change after heating and later after mercury has become reoxidized. Test gas from heated HgO with glowing splinter.	test tube burner Erlenmeyer flask sulfur iron filings
Chemical changes which require energy to be put in are called endothermic changes or	Repeat and discuss several demonstrations. Concentrated sulfuric acid on sugar--allow pupils to note	

CONTENT	LEARNING EXPERIENCES	MATERIALS
reactions and chemical changes which give off energy are called exothermic reactions.	color change and heat produced. Do the same with zinc and HCl. Discuss burning of coal--need to initiate action with heat but heat from burning will be adequate to cause carbon and oxygen to combine giving off even more heat. Heat iron and sulfur to form FeS.	
	Discuss endo-and exo-. Use example such as entrance, exit, endo- and exo-skeleton.	
	Post test.	examination

APPENDIX K

THE PRE AND POST TEST

1. The word element means a substance which has:
   a. atoms with nuclei with the same number of neutrons.
   b. atoms with nuclei with the same number of electrons.
   c. atoms with nuclei with the same number of protons.
   d. atoms that all have the same atomic weight.

2. A certain kind of molecule always has:
   a. the same number of atoms.
   b. the same elements in the same amount.
   c. the same chemical properties.
   d. all of the above answers.

3. Conservation of matter during chemical reactions can be shown best by:
   a. weighing the chemicals before and after they react.
   b. comparing the heat lost or gained during the reaction to the temperature before the reaction.
   c. measuring the weight of the chemicals before the reaction and the amount of heat lost during the reaction.
   d. weighing an amount of solute and an amount of solvent, mixing the two, and weighing the solution.

4. When iron and sulfur are heated to form iron sulfide, the compound:
   a. weighs less than the amount of iron and sulfur used.
   b. weighs the same as the amount of iron and sulfur used.
   c. weighs the same as the amount of iron and sulfur used plus the weight of the gas used in heating.
   d. weighs more than the amount of iron and sulfur used.

5. Matter is different from things which are not matter because:
   a. matter takes up space.
   b. matter has weight.
   c. matter usually expands when heated.
   d. all of the above answers are correct.

6. When silver nitrate and sodium chloride are combined:
   a. a black precipitate is formed.
   b. no chemical reaction takes place.
   c. a white substance is formed.
   d. two new equally soluble substances are formed.

7. A compound is made of:
   a. two or more <u>unlike</u> atoms chemically combined.
   b. two or more <u>like</u> atoms chemically combined.
   c. two or more <u>like</u> atoms physically combined.
   d. two or more <u>unlike</u> atoms physically combined.

8. When concentrated sulfuric acid is placed on table sugar:
   a. nothing happens until the two materials are heated.
   b. the sugar melts and forms a solution with the sulfuric acid.
   c. a brown or black material is formed.
   d. the sulfuric acid gradually becomes whitish in color.

9. The nucleus of the atom usually contains:
   a. electrons and protons.
   b. protons and neutrons.
   c. neutrons and electrons.
   d. protons only.

10. One of two substances forming a mixture might be separated from the mixture by:
    a. evaporating.
    b. dissolving.
    c. magnetism.
    d. any of the above ways depending on the mixture.

11. When a solute and a solvent are mixed:
    a. the solute dissolves in the solvent.
    b. a chemical change takes place.
    c. a physical change takes place.
    d. more than one of the above answers is correct.

12. When forming ice from ice water:
    a. a contraction takes place.
    b. the ice becomes heavier.
    c. an expansion takes place.
    d. the water loses molecules making the ice lighter.

13. When table salt is mixed with water:
    a. a solution is formed.
    b. water acts as the solute.
    c. a solute dissolves in a solvent.
    d. more than one of the above answers is correct.

14. The number of natural elements (Not made by man) is:
    a. 82
    b. 90
    c. 92
    d. 96

15. According to the principle that matter cannot be created or destroyed, when coal burns:
    a. the weight of the coal and the weight of the gas (oxygen) used in burning should weigh as much as the ashes and the gas produced in burning.
    b. the gas produced in burning and the ashes should weigh as much as the coal.
    c. the gas produced in burning should weigh the same as the gas used in burning.
    d. the ashes should weigh as much as the coal.

16. Compounds are different from mixtures in that:
    a. compounds have more elements.
    b. compounds have a definite number of atoms.
    c. compounds have properties or characteristics.
    d. compounds have fewer molecules.

17. A molecule might be made of:
    a. two or more unlike atoms chemically combined.
    b. two or more like atoms chemically combined.
    c. two or more like atoms physically combined.
    d. more than one of the above answers.

18. The burning of coal or gas can be called an:
    a. endothermic reaction.
    b. oxythermic reaction.
    c. exothermic reaction.
    d. orthothermic reaction.

19. Protons, neutrons, and electrons take up space, have weight, and are:
    a. matter.
    b. part of the nucleus of the atom.
    c. of about equal weight.
    d. more than one of the above answers.

20. Which of these is a chemical change?
    a. evaporating a liquid.
    b. burning a gas.
    c. boiling a liquid.
    d. melting a solid.

21. If you walked by a bakery and smelled the odor of baking bread you should know:
    a. a chemical change <u>only</u> had taken place.
    b. chemical and physical changes had taken place.
    c. a condensation, but no chemical change, had taken place.
    d. an evaporation, but no physical change, had taken place.

22. Anything which takes up space and has weight can be called:
    a. solid.
    b. mixture.
    c. gas.
    d. matter.

23. Carbon twelve would be expected to have:
    a. an atomic weight of about twelve.
    b. twelve protons.
    c. twelve neutrons.
    d. twelve protons and twelve neutrons.

24. Uranium can be in several forms. Uranium 235 has 92 protons. This means that uranium 235 has:
    a. 143 electrons.
    b. 143 neutrons.
    c. 235 electrons.
    d. 235 neutrons.

25. Which of the following is a physical change?
    a. evaporation.
    b. condensing.
    c. boiling.
    d. all three are physical changes.

APPENDIX L

THE LESSON PLANS

LESSON I

Purpose: To introduce the unit to the students.
To test the students for their present knowledge concerning this unit.

Procedure:

1. Explain that this unit has been planned to help them learn about some areas of chemistry.
2. Describe several areas of chemistry that the students will work in.
   a. Atoms--Show a complex picture of an atom.
   b. Measure and weight--Show student several different balances to be used.
   c. Types of matter--Show students a block of wood and a beaker of sand. Do not explain these items, but ask several questions about them to the student, such as, "Are these both matter?", "How are they the same?", "What kind of matter are they?"
3. Explain that they may know about and have used some materials before, but now they are going to be used in a sequence. Each part of the unit is used to teach something important to help them in learning another part.
4. Tell the students that they are now going to take a test to let them tell the things they already know and how well they know them.
5. Instructions and test given.

Time:	6th grade	5th grade
	50 minutes	1 hours

LESSON II

Purpose: To define with student help the areas of study with which chemistry is concerned. (Chemistry is the study of what matter is made of, the properties of the matter, and the changes that can occur to matter.)

Procedure:

1. Explain to students that some items we know are matter and that some are not. Tell student, "I would like

to find out which items you think are matter and which are non-matter." Make two lists on the board (matter and non-matter) and have student name items to be put in each list.

2. Discuss these groups. (Sample non-matter: ideas, beliefs, feelings, words, noise, faith, light, heat). Leave this material on the blackboard.

3. With student help through discussion, build a definition of chemistry. Then with it, give the definition commonly used by chemists.

4. Tell students that recording procedurs, results and conclusions is probably the best way to be sure of what they have done. Using an historical example, explain the importance of recording in science. Then explain the notebook they are to build during this unit. Have a chart with the table of contents. Explain each item.

a. Daily review of ideas studied.
b. Vocabulary and definition of terms listed.
c. Laboratory instruction sheets.
d. Demonstration sheets.
e. Review of films.
f. Test and quizzes.

5. Help students set up notebook and record necessary information from present lesson.

Time:	6th grade	5th grade
	35 minutes	50 minutes

LESSON III

Purpose: To help student develop a concept of matter and its properties. (Matter is anything which takes up space and has weight).

Procedure:

1. Use balance to weight various items. Discuss each item before weighing it and then develop a conclusion about it. Try to weigh the word "rock" and then weigh a rock. Use the word "book" and then weigh a book. Weigh other items from the lists made in Lesson #II. Ask students leading questions as to which items are matter and why they believe it is matter. Ask students leading questions as to what all items that are matter have.

2. Have jar of water with some air in it. Mark the level of the water with a felt pen. Add a rock to the water; note the new water level. Ask students if the jar is now fuller. Have students explain their answers. Through this discussion help students develop the concept that rock, air, and water all occupy space. Illustrate to student by placing a

jar of air upside down into a pan of water. Heat this container so pupils can see air escape into the water.

3. Fill a balloon with air and submerge in a pan of water with a mark at the water level. Note the new water level after the balloon is under water. Ask the students why the water level changed. Ask what did the balloon and air do in the water. Ask if they need to be in the water to take up space.

4. Illustrate that air occupies space and has weight by weighing a ball, then filling it with air and weighing it again. Note what happens to the ball as it is filled with air. Record on the blackboard the weight of the ball before and after filling with air.

5. Review definition of matter and demonstrations for recording in notebooks.

Time:	6th grade	5th grade
	40 minutes	50 minutes

LESSON IV

Purpose: Help students develop concent of differences in matter.

Introduce students to laboratory work and procedures.

Procedure:

1. Set up materials which students are to examine on the tables in the lab room beforehand and mark certain necessary items DO NOT TASTE.

2. Before taking the students into the lab room, give directions. They are to examine the various kinds of matter and describe them in their own words, trying to use single words or phrases. Remind them to use the information they learned so far in this unit. Caution students about tasting.

3. Take students in lab room, give directions on rotating procedures and amount or time for each item. Have items in large circle and use movements to the left. Give students one full minute per item. Then quickly take students back to their room. Bring items from lab room to classroom.

4. Make a list on the board of ways the students used to describe the types of matter. Ask students to explain which descriptions will fit the most items and which best describe groups of matter.

5. Try to have the pupils list all the types of matter which have one thing in common; either having a definite shape or not having a definite shape.

6. Try to have pupils separate items not having a definite shape into those which stay in a container and those which do not. The three groups of matter should be put in front of the class at this time to help students.

7. Record daily concepts.

<u>Time</u>: <u>6th grade</u> 40 minutes — <u>5th grade</u> 50 minutes

LESSON V

<u>Purpose</u>: Demonstrate to the students the special characteristics of certain types of matter. (Sometimes solids may have characteristics of a liquid. A gas may have the characteristics of a liquid.)

Help students form definitions for concepts of matter, solids, liquids, gasses, to be put in notebooks.

<u>Procedure</u>:

1. Ask the students what type of matter sand is. Ask about salt and flour also. Illustrate by pouring sand into a beaker. Do same with flour and sugar. Discuss student ideas and help them develop the idea of sand as a plural.

2. Show to students a quart jar of CO_2 gas (dry ice) which will tend to stay in the jar for the demonstration. Ask the students what type of matter is in the jar. Discuss student ideas and help them come to a conclusion.

3. Write definitions for solid, liquid and gas on the board using student suggestions. (See unit)

4. Record definitions into notebooks under vocabulary.

5. Record daily concepts.

<u>Time</u>: <u>6th grade</u> 30 minutes — <u>5th grade</u> 40 minutes

LESSON VI

<u>Purpose</u>: To help students gain the concept that matter changes forms.

To help students understand ways in which matter changes form.

Procedure: Present demonstrations and help students discuss them.

1. Heat ice and butter. Ask students before items are heated what types of matter they are (solids). After heating ask them only, "What happened to the matter?"
2. Cool warm gelatin, cool liquid butter. Before items are cooled, ask students what form of matter they are (liquids). After cooling in ice with salt, ask students, "What happened to the forms of matter?"
3. Heat water until vapor is clearly seen. Ask students what is happening to the water. Lead students to concept of evaporation. Then ask students what the matter is called that is rising from the pan. Emphasize this is vapor and not steam. Then place cold pan above the water. Ask student what is happening to the vapor.
4. Place benzaldehyde or cheap perfume in an open container. Ask students what form of matter it is. (liquid). Ask children to detect odor. Then discuss evaporation further. Use examples of cooking odors, melting snow, gas in car from liquid to vapor.
5. In notebooks, students record demonstrations. Review daily concepts. (Matter can be changed from one form to another in sever ways: 1. Solid to liquid by heating. 2. Liquid to solid by cooling. 3. Liquid to gas by heating. 4. Gas to liquid by cooling.)

Time:	6th grade	5th grade
	40 minutes	40 minutes

LESSON VII

Purpose: Review changes in matter and concepts of solid, liquid and gas.

Procedure:

1. Review concept from yesterday--matter can be changed in form. Review ways (solid to liquid, liquid to solid, liquid to gas, gas to liquid).
2. Show film, "Solids, Liquids, Gasses".
3. Discuss concepts demonstrated and explained in the film.
4. He p students write a review of the film for notebook.

Time:	6th grade	5th grade
	25 minutes	25 minutes

LESSON VIII

Purpose: To help students continue to develop a concept of solute and solvent.

To illustrate to students what solutes and solvents are.

To help students develop an understanding of materials dissolving.

Procedure:

1. Mix oil and water together in a beaker. Then mix water and salt in a beaker. Ask the students what differences they see between the mixtures. Help students explain that in one beaker the oil and water remain in separate parts, while in the other beaker, the salt and water are not separate.

2. Explain to them that when particles of matter can be separated from each other by a liquid, we say the matter has been dissolved.

3. Demonstration. Mix sugar and water together. Ask students if any matter is dissolved. What? Explain to the students that when matter dissolves in other matter, the matter that dissolves is called solute, and the matter in which other matter is dissolved is called solvent. The one present in larger amount is solvent.

4. Put Crisco into a beaker of alcohol and stir. Then ask the students to explain what has happened, using the new words they have learned.

5. Put some butter into a beaker of chloroform and have a student explain this demonstration.

6. Put some oil into a beaker of alcohol and ask a student to explain what happened. Then put the beaker of oil and water next to it and ask a student how the two are alike and how they differ. Bring out the concept that different solutes will dissolve in different solvents but not in any liquid.

7. Ask a student which is more in quantity, the solute or the solvent. Demonstrate with salt and water.

8. Review terms for notebook and pass out demonstration sheets.

Time:	6th grade	5th grade
	40 minutes	50 minutes

LESSON IX

Purpose: To help students gain a realization of the effect of heating ahd cooling of matter upon the amount of space occupied by the matter.

To help students gain a realization that different forms of matter fo not increase in size with same amount of heat.

Procedure:

1. Ask student what happened to matter when it is heated. Develop discussion around these answers.

2. Show students demonstration of heating effect on the brass ring and ball.

a. Describe ring and ball relationship.
b. Heat ball and describe ball and relationship to the ring.
c. Then heat ring and describe.
d. Cool ring and describe.
e. Cool ball and describe.

Ask students if they observed any other effect of heating. Cooling? Discussion.

3. Show students demonstration with flask of water, one hole cork and tube. Ask students how the heating affected the water. Then cool the flask. Ask students how the cooking affected the water.

4. Heat and cool a thermometer. Record the high and low on the board. Draw model on the board and have a student explain what happened to the mercury.

5. Demonstrate effect of heating on a flask covered with a balloon. Ask students to observe what happens. Ask what happened and why. Ask what matter expanded.

6. Heat a bimetallic rod. Ask students to try to explain what happened. Note curve and ask reason for it. Then cool rod and note results.

7. Review daily concepts for notebooks using students' generalizations. Pass out demonstration sheets and have students tell what happened in each demonstration.

8. Discuss the exception of ice--water. Expansion in freezing, condensing in forming water, still the same kind of matter.

Time:	6th grade	5th grade
	40 minutes	50 minutes

LESSON X

Purpose: To help students gain an understanding of physical changes.

To review effects of physical change.

Procedure:

1. Make a quick review of effects of heating and cooling of matter. Do this by asking certain pupils what happened in the experiments they saw yesterday. (Made changes in for or size).

2. Observe film, "Learning about Heat". Discuss demonstrations shown and definitions given. Assign film report.

3. Give students a chance to ask specific questions about physical changes and tell about other physical changes they know about. Put definition of physical change on board. Have students put these in their notebooks.

4. Short quiz--ditto.

Time:	6th grade	5th grade
	35 minutes	50 minutes

LESSON XI

Purpose: To help students gain a concept of mixtures.

To help students gain an understanding of ways possible to separate the types of matter in various mixtures using physical means.

Show students some common ways of separating mixtures (evaporation, magnetism, dissolving.)

Procedure:

1. Discuss with pupils what mixtures are. Relate the study of solutes and solvents. Show and discuss some common mixtures (cocoa and milk, salt and water). List others students know on the blackboard.

2. Prepare the following mixtures and have pupils observe these.

   a. Sugar and water. Boil water away and show students the sugar.

   b. Food coloring and water. Boil and condense water from mixture of food coloring and water.

   c. Iron filings and powdered sulfur. 1. Use a magnet to pick out iron filings. 2 Use CS_2 to dissolve sulfur.

3. Mix sugar and sand and let students give method for separating the mixture. (Use water.) Then ask how to separate sugar from water. Show as demonstration.

4. Discuss new terms for notebooks.

a. mixture
b. dissolving
c. evaporation
d. magnetism
e. physical

5. Review daily concept for notebooks.
   a. Different kinds of matter can be mixed and different forms of matter can be mixed.
   b. Some mixtures are like the dissolving of a solute in a solvent.
   c. When mixtures are made, it is often possible to separate the types of matter by physical means.
   d. Some common ways of separating mixtures are by evaporating, using magnetism, and dissolving.

6. Pass out demonstration sheet with questions about how each mixture was separated.

Time:	6th grade	5th grade
	30 minutes	50 minutes

LESSON XII

Purpose: Show to the students that the weight of matter produced when making a mixture is equal to the total or combined weights of matter used in making the mixture.

Help students develop a realization of the concept that matter cannot be created or destroyed by mixing.

Introduce students to the idea of a chemical change.

Procedure:

1. Use questions to help students prepare for deminstration. Ask such as: When items are mixed, does the total weight equal the sum of the parts? Questions on volume may develop--be prepared.

2. Demonstration: Weigh a beaker of water and record weight on board. Weigh some sugar, record on board, and mix the sugar with the water. Weigh again and compare the weights. Do the same demonstration with iron filings and sulfur.

3. Discuss the difference between chemical change and what we have done so far. Use example of adding sugar to water, which even though the sugar disappeared in the

water, the end result was still the same sugar and water.

4. Review daily concepts for notebook
   a. The amount of matter produced when making a mixture is equal to the total amount of matter used to make the mixture.
   b. Matter cannot be created or destroyed by mixing.
   c. Matter by weight cannot be created or destroyed by chemical means.

<u>Time</u>: <u>6th grade</u> 45 minutes — <u>5th grade</u> 50 minutes

LESSON XIII

<u>Purpose</u>: Show other examples of chemical changes to students.

Help students gain an understanding of change in matter by burning, uniting, or changing in some other way, but that matter cannot be created or destroyed by chemical means.

<u>Procedure</u>:

1. Burn a piece of paper with students observing. Ask them what was left. (Ashes, smoke, develop understanding of possibility of a gas). Explain that the combined weights of these new forms of matter would equal the weight of the wood, <u>plus</u> the weight of the oxygen added for burning.

2. Tell students, we will try to observe the change and record the weight in a chemical change. Weigh the sugar and beaker. Then add Concentrated H_2SO_4 by weight to the sugar in a closed container (careful with amount of acid). Weight the product and compare to the combined weights of the sugar, beaker, and amount of acid used. (It may be slightly less due to escape of gas.)

3. Explain that some chemical changes occur without burning. Weigh an amount of silver nitrate solution and an amount of sodiumchloride solution. Put them together and note the precipitate. Then weigh the product. Discuss meaning of precipitate.

4. Review today's concepts for notebook.
   a. We can change matter by chemical means.
      1. We can change matter by burning.
      2. We can change matter by causing two materials to unite or by causing materials to change about in some way.

LESSON XIV

Purpose: Thorough evaluation of student learning of material presented.

Procedure:

Give thorough quiz over first part of unit.

Time:

6th grade	5th grade
35 minutes	40 minutes

b. Review of physical and chemical change.
   1. Changes in form or size of matter are called physical changes. Review examples.
   2. When matter is mixed, we usually can separate the types of matter in the mixture by physical means. Review examples.
   3. The amount of matter remains the same.
   4. We can change matter by chemical means. Review examples.

Time:

6th grade	5th grade
40 minutes	50 minutes

LESSON XV

Purpose: Help develop student awareness of the small size of particles called atoms.

Help students to develop a concept that when matter is made up of only one kind of atom, it is called an element.

Expand students' knowledge of various elements found by man and those man has made.

Help student gain a working vocabulary of certain elements and their symbols.

Procedure:

1. Develop a discussion of concept of atom. Have students present their own knowledge through this discussion. Use examples of other familiar, small items to help student develop understanding of the size of atoms.

2. Help students clarify the concept of atom. Have students give names of things they believe are made of one kind of atom and make a list of them on the blackboard. After enough various items are listed, stop. And then go through the list explaining to the students which items are made of one type of atom and which are not. Be sure to stress those items which are not elements--are made up of more than one kind of atom.

3. Explain that there are many different types of atoms and each has different properties which makes it different from any other.

4. Explain that scientists once had difficulty in understanding atoms also, but that through hard work they have distinguished 92 natural elements and then were able to make some others. Introduce student to the periodic chart

and explain that it shows each element and that they are in patterns as to similar properties.

5. Explain to the student that each element has a symbol. Put several on the blackboard and explain these symbols are similar to the symbols we use for the words in numbers. Make a list on the board of the elements the student should learn--especially; hydrogen, oxygen, gold, silver, carbon, nitrogen, chromium, neon, aluminum, copper, nickel, iron, sulfur, tin, chlorine, mercury, sodium, uranium, plutonium.

Pass out ditto paper of elements and symbols and have student give symbols for the elements listed on the board. Stress to students that they will be expected to learn the names of the common elements and their symbols.

6. Review daily concepts for notebooks:

All matter is made of very small particles called atoms.

Matter when made up of only one kind of atom is called an element.

There are many different types of elements, each will have separate properties.

Each element has a name and a chemical abbreviation or symbol.

92 elements have been found--others have been made.

Time:	6th grade	5th grade
	45 minutes	35 minutes

LESSON XVI

Purpose: Review chemical symbols for reinforcement.
Have a short lab to help students see some of the different properties of various elements.
Develop student understanding of certain aspects of the concept, subatomic.

Procedure:

1. Give students a ditto sheet with 20 common elements listed on it. Below have the symbols in a random order. Put directions on paper to have students put correct symbol beside each element.

2. While students are completing quiz, set out a number of elements for lab. Divide group into pairs and let each pair write separate short word descriptions of each element. Then in class discussion describe each element. Collect description sheets from each student.

3. Review concept of atom using a class discussion. Introduce word concept subatomic. Relate discussion of smallness of atom to subatomic. Explain to students that all atoms

are made of these subatomic particles. (Develop vocabulary.)

4. Sketch and describe for students the nucleus of an atom showing protons and neutrons. Discuss each. Do not be concerned with charges.

5. Introduce relative position of electron in sketch. Discuss differences in weight among the subatomic particles.

Proton and neutron weigh about the same.

Electrons weigh about 1/2000 as much as a proton. Relate this to a pound weight compared to a ton. Then use a one-ounce weight as compared to various combinations of students of 125 pounds.

6. Review daily concepts for notebooks.

Atoms of each element are made up of very small subatomic particles. All atoms have these particles.

The three subatomic particles which seem most important to chemistry are proton, neutron and electron.

The atom is usually pictured with a central heavy part called the nucleus. In the nucleus are the proton and the neutron.

The proton and neutron weigh about the same, while the electron weighs only 1/2000 as much as the proton.

Time:	6th grade	5th grade
	45 minutes	50 minutes

LESSON XVII

Purpose: To help students gain an understanding of the way which subatomic particles are located in the nucleus.

1. To help students learn the number of protons in the nucleus of the atom of an element is always the same.
2. To help students understand the concept that the number of protons is the atomic number of the element.
3. To explain various elements and their atomic numbers for students.
4. To explain to students that in lighter elements (which are those with smaller numbers), the number of neutrons is often about equal to the number of protons, and since electrons weigh so little, the atomic weight is about equal to the number of protons and neutrons combined.
5. To explain to students that the number of neutrons can often be determined by subtracting

the atomic number from the atomic weight.
6. To develop student understanding of location of electrons and the number of electrons.

Procedure:

1. Short quiz on chemical symbols.

2. Explain to students atomic structure and that the protons are always in the nucleus. Explain that the number of protons in the nucleus of an element is always the same. Use a periodic chart to locate atomic numbers and discuss this number and its relation to the number of protons. Use several examples--hydrogen, carbon, oxygen, etc.

3. Sketch nuclei of various different elements to show students the number of protons and neutrons. Through discussion, develop that this is the atomic weight. Make sure all students know the difference between atomic number and atomic weight, and how to find the number of neutrons.

4. Explain to students position of electrons (some distance away in a cloud) and show how they are pictured. Explain that usually the number of electrons is equal to the number of protons. Develop through discussion that the more electrons, the further away the outer ones are.

5. Review daily concepts for notebooks. Use part 1 for guide in discussion.

Time:	6th grade	5th grade
	45 minutes	45 minutes

LESSON XVIII

Purpose:

Have students work with terms electrons, neutrons, protons, and nucleus in making atomic structures and nuclear arrangements.

Have students gain an understanding of calculating the atomic weights of differene elements depending upon the number of protons, neutrons, and electrons and representing them on paper with seeds. Practice in calculating number of neutrons from atomic weight and number.

To develop student understanding of an atomic mass unit being equal to the proton.

Procedure:

1. Have five large cardboard sheets with the outline of the nucleus and electron shells on each. Divide students into five groups and explain that they will be assigned an element to show the structure of on the sheet. Demonstrate on a simple element and then assign an element to each group.

Give working time. (Use clay with pins to hold pieces against cardboard.)

2. Discuss model made by each group. Let them review the way they figured the numbers for the particles. Develop concept of atomic mass unit.

3. Pass out ditto sheets and various seeds and have pupils build models of several elements and calculate the atomic weights. Give atomic number to work from and then give atomic weight to work from.

4. Review daily concepts--see Purpose. (Not for notebooks). Have students make drawing of several common elements on ditto sheets for lab section of notebook.

Time:	6th grade	5th grade
	50 minutes	70 minutes

LESSON XIX

Purpose:

a. Give quiz to determine understanding of previous concepts concerning atomic structure.
b. To develop student understanding that very heavy elements have a large number of neutrons and protons.
c. To help students learn symbols for neutron, electron and proton.
d. To help students understand various atomic weights (isotopes) of uranium.
e. To help students understand why such atoms are often unstable.
f. To help students develop a concept of atoms of an element combining to form a molecule.

Procedure:

1. Reveiw ideas for past two days for notebook.

2. Give instructions and pass out ditto quiz. Allow ample working time.

3. Review discussion of protons. Develop discussion of neutrons in an atom and that sometimes the number can vary--use carbon (neutrons - 5,6,7,8,9) as an example. Introduce term isotope.

4. Have pupils compute the number of protons and neutrons in isotopes of other elements using the atomic weights from the periodic chart. Oxygen, sulfur, fluorine, chlorine. Tin ten isotopes.

5. Discuss the concept of molecules. Define idea of molecules of an element and demonstrate using models.

Demonstrate that the manner that we can use to fasten the atoms together are various, but that atoms are not fastened in these manners but in some manner. Use oranges and a toothpick, beans and glue, pencils and rubber bands.

6. Have students diagram molecules of oxygen, hydrogen, chlorine, bromine. Explain how symbols are written (O , H , Cl , Br)

7. Review daily concepts for notebooks. (See Purpose b-f.)

Time:	6th grade	5th grade
	40 minutes	60 minutes

LESSON XX

Purpose:

Help students develop a concept of compound.
Help students develop an understanding of what various compounds are made of.
To help students understand that some compounds are made up of a number of different atoms.
Help students develop an understanding of the Law of Definite Proportions.

Procedure:

1. Review molecules. Discuss molecules and use sketches on the board to show compounds. Sketch and describe several compounds which have only two unlike atoms--CO, Co , H O, NaCl, NH .

2. Have students make simple sketches showing the atomic structure of the atoms composing molecules of the compounds indicated above on a sheet of paper. Hand out ditto for each.

3. Discuss more complex compounds with which students are familiar. (Vinegar--CH COOH; table sugar C H O ; sulfuric acid in car batteries--H SO). Show these to students. Label and display.

4. Discuss the idea that the atoms which form a molecole always occur in the same amount of number. Water, carbon dioxide.

5. Develop student understanding of Law of Definite Proportions. Discuss need for amount in proportion before compound can form. Use H SO as example.

6. Review daily concepts. (See Purpose).

Time:	6th grade	5th grade
	40 minutes	50 minutes

LESSON XXI

Purpose: Review of student understanding--quiz.
Develop student understanding of molecules as building blocks of matter.
Develop student understanding of different compounds.
Develop student understanding of compounds being used to produce other compounds.

Procedure:

1. Quiz on material and concepts presented from mid-unit test.

2. Through a rediscussion of matter, emphasize the detail we have used in studying matter. Suggest that matter is a general term and review the building blocks which form matter.

3. Discuss what can be made from these building blocks. Show students some actual compounds; salt, sugar. Discuss the properties of these compounds.

4. Lab. Group students and each group will describe a certain compound and present their description to the class.

5. Discuss the use of various compounds--solvents, fuels.

6. Review daily concepts for notebooks.

Time:	6th grade	5th grade
	40 minutes	50 minutes

LESSON XXII

Purpose: To help students form an understanding that to form a compound from various atoms or to make one compound from another is called a chemical change.
To help the students understand that all chemical changes require that energy either be used or given off for the change to take place and use terms endothermic and exothermic changes or reactions.
Review conservation of matter in chemical changes.

Procedure:

1. Show the changing of material to produce other materials to students. Burn a piece of paper. Discuss the reaction that took place and the products of the reaction. Do the same with acid on zinc--let product pop. Heat mercuric oxide and produce oxygen. Test. Then note color change

after heating and a few minutes later.

Discuss what had to be in order for the reaction to occur--heat.

Discuss burning of coal--need to initiate action with heat, but heat from burning will be adequate to cause carbon and oxygen to combine, giving off even more heat.

Review chemical change showing the heating of iron and sulfur to form FeS.

Introduce and discuss endo and exo.

2. Re-demonstrate conservation of matter during a chemical change.

3. Review daily concepts. See above.

Time:	6th grade	5th grade
	40 minutes	30 minutes

LESSON XXIII

Purpose: Review concepts of atoms, elements and molecules. Help students gain an understanding of the relationship of solutions, mixtures, and compounds.

Procedure:

1. Start discussion with students concerning what they learned and some of the parts they enjoyed. Be sure that the following concepts are discussed: atom, element, molecule.

2. Show students a sample of a solution, a mixture, and a compound. Develop a discussion with the students of the relationships between these items.

   a. They are all matter.
   b. They are all made of atoms.
   c. They cannot be destroyed under ordinary conditions.
   d. They all can be changed by physical means.
   e. The solution and mixture were formed by physical means.
   f. The compound was formed by chemical means.
   g. They all can be changed by chemical means.

Time:	6th grade	5th grade
	30 minutes	30 minutes

APPENDIX M

THE EQUIPMENT AND MATERIALS

LESSON 1

Weights, scale, balance, pictures of atoms, wood block, beaker of sand.

LESSON 2

Materials for student notebook.
Chart of table of contents

LESSON 3

Weights, balance, rock, jar, water, 1 gal. aquarium, felt pen, balloon, new play ground ball, air pump, demonstration sheets.

LESSON 4

Labeled containers of alcohol, water, ammonia, oil, syrup, gasoline: Closed containers of iodine, wood, rock, coal, butter, rubber stopper.
Labels for all items.

LESSON 5

3 beakers, flour, sand, sugar, mason jar and cap, dry ice.

LESSON 6

Ice in pan, butter, warm gelatin, pan of water, burner, tripod, gauze, spoon, benzaldehyde or perfume in shallow container.

LESSON 7

Film, projector, screen.

LESSON 8

Containers of butter, sugar, salt, water, oil, chloroform, alcohol, Crisco, 6 beakers, large pan.

LESSON 9

Brass ring and ball set, burner, tripod, gauze, balloon, 2 erlenmeyer flasks, rubber stopper with glass tube, pan of ice, pan of cold water, beaker of water with food coloring, bimetallic rod.

LESSON 10

Film, projector, screen. Quiz.

LESSON 11

Salt, cocoa, milk, large jar of water, 6 medium beakers, iron filings, sulfur, CS_2, magnet, burner, 1 erlenmeyer flask, rubber stopper for flask - 1 hole - with glass tubing to condense water, food coloring, tripod, gauze.

LESSON 12

Iron filings, sulfur, sugar, jar of water, 1 beaker, 1 dish, balance and weights.

LESSON 13

Sugar, H_2SO_4(conc.), balance and wdights, paper to burn, pan, silver nitrate solution, sodiumchloride, large erlenmeyer flask, cork for flask.

LESSON 14

Quiz.

LESSON 15

Periodic chart, ditto list of elements and symbols with common ones marked.

LESSON 16

Quiz, periodic chart, ounce weight, pound weight. Elements: carbon, zinc, copper, tin, nickel, magnesium, sulfur, chromium, aluminum, iron, lead: lab sheets with instructions.

LESSON 17

Film - A is for Atom, projector, screen. Periodic chart.

LESSON 18

Periodic chart, 10 cardboard sheets--five each class
clay--red, blue, yellow
Pins, ditto sheets, 3 groups of various colored seeds.

LESSON 19

Quiz, periodic chart, large chart with diagram of atom of uranium, oranges, beans, pencils, rubber bands, glue, sticks.

LESSON 20

Pencils and rubber band, vinegar, table sugar, sulfuric acid, salt, ditto sheets for sketches.

LESSON 21

Quiz, lab. sheet, salt, sugar, protein, water, gas, alcohol.

LESSON 22

Paper, wood splints, HCl, zinc, conc. H_2SO_4, HgO, four test tubes, burner, erlenmeyer flask, sulfur, iron filings, sugar, large erlenmeyer flask with cork, balance, weights.

LESSON 23

Solution, mixture, compound.

APPENDIX N

THE ATTITUDE TEST

Below are several statements concerning chemistry. Your task is to indicate the degree to which you agree or disagree with the thoughts expressed by each of the statements. Respond by circling the appropriate number. Consider the numbers to be equally spaced along a continum. That is, the difference between 1 and 2 is equal to the difference between 6 and 7.

1. Chemistry is a boring subject.

disagree			neutral			agree
1	2	3	4	5	6	7

2. Knowledge of chemistry promotes social status.

disagree			neutral			agree
1	2	3	4	5	6	7

3. People who want to be practical should have a basic knowledge of chemistry.

disagree			neutral			agree
1	2	3	4	5	6	7

4. Understanding chemistry leads to success in life.

disagree			neutral			agree
1	2	3	4	5	6	7

5. The thought of having to study chemistry is frightening.

disagree			neutral			agree
1	2	3	4	5	6	7

6. Studying chemistry should be avoided whenever possible.

disagree			neutral			agree
1	2	3	4	5	6	7

7. Studying chemistry leads to confusion of facts about nature.

disagree			neutral			agree
1	2	3	4	5	6	7

8. Studying chemistry is for boys only.

disagree			neutral			agree
1	2	3	4	5	6	7

9. Chemistry has done very little to benefit mankind.

disagree			neutral			agree
1	2	3	4	5	6	7

10. Chemistry is evil.

disagree			neutral			agree
1	2	3	4	5	6	7

11. Studying chemistry is for girls only.

disagree			neutral			agree
1	2	3	4	5	6	7

12. Studying chemistry is a waste of time.

disagree			neutral			agree
1	2	3	4	5	6	7

13. Only an idiot would waste his time studying chemistry.

disagree			neutral			agree
1	2	3	4	5	6	7

14. Good citizens should study chemistry.

disagree			neutral			agree
1	2	3	4	5	6	7

15. Chemistry helps promote logical thinking.

disagree			neutral			agree
1	2	3	4	5	6	7

16. An understanding of chemistry is helpful later in life.

disagree			neutral			agree
1	2	3	4	5	6	7

17. Chemistry is the most important science.

disagree			neutral			agree
1	2	3	4	5	6	7

18. Chemistry is a lot of fun.

disagree			neutral			agree
1	2	3	4	5	6	7

19. People study chemistry because it is exciting.

disagree			neutral			agree
1	2	3	4	5	6	7

20. Chemistry is a fascinating hobby.

disagree			neutral			agree

21. Knowledge of chemistry provides a basic understanding of life.

disagree			neutral			agree
1	2	3	4	5	6	7

22. Chemistry is interesting.

disagree			neutral			agree
1	2	3	4	5	6	7

23. Students should be required to take chemistry.

disagree			neutral			agree
1	2	3	4	5	6	7

24. Most chemistry majors are very intelligent people.

disagree			neutral			agree
1	2	3	4	5	6	7

25. People study chemistry because it is a necessity.

disagree			neutral			agree
1	2	3	4	5	6	7