THE DEVELOPMENT AND EVALUATION OF VOCATIONAL SCIENCE 103 AT KILDONAN EAST REGIONAL SECONDARY SCHOOL

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EDWARD C. BULLER

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OF
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A dissertation submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements of the degree of

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INTRODUCTION

A. The Problem

During the academic year 1972-73, the first full year of operation of Kildonan East Regional Secondary School, a comprehensive high school in the City of Winnipeg, it became apparent that the existing Vocational Science Curriculum was unsuited for the needs of vocational students. It was at this time that an alternative curriculum was developed.

The purpose of this paper is to describe the development and evaluate the effectiveness of Vocational Science 103, the first level of the alternative curriculum.

B. Rationale

Since 1964 Manitoba high schools have seen the introduction of numerous improved Science curriculum materials. PSSC Physics, CHEMS Chemistry, BSCS Biology, IPS, and IME are the most common in Manitoba. The majority of these new curriculum materials were designed for the average and the better than average student. It was felt that this indicated a definite problem area, for as Bruner had warned in 1960,

> Improvements in the teaching of Science and Mathematics may very well accentuate the gaps already observable between the talented, average, and slow students in these courses.[1]

Later, in 1971, Paul Hurd made a similar observation when he wrote,

> The majority of the new Science courses were developed for college preparatory students, especially the courses in Chemistry and Physics, and, to a lesser extent, the Biology courses. At a later time a course in Biology was developed for the "slow learner". It is quite evident that we do not have Science courses suitable for the full range of student abilities in secondary school.[2]

The gaps between students of different abilities described by Bruner, as well as the lack of suitable courses for the full range of secondary school students described by Paul Hurd, were both evident at Kildonan East Regional Secondary School.

In specific terms, it was felt that the existing Department of Education curriculum outlines for vocational science did not effectively consider the unique characteristics of the vocational student nor did they satisfy the requirements of the vocational curriculum.

C. Definition of the Problem

This study will describe the development and evaluate the effectiveness of Vocational Science 103. It will describe course development by articulating the specific steps taken in preparing the curriculum. It will evaluate by answering two questions:

i) To what degree did the students in the sample meet the instructional objectives of Vocational Science 103?

ii) Did students' attitudes toward the study of Science show a significant positive change during the period of instruction?

D. Hypotheses

This study has 2 primary components: Course development and course evaluation. Course development is of a descriptive nature and will be treated accordingly. Course evaluation, however, is of a statistical nature, and thus, may be expressed in the form of 3 hypotheses:

i) An achievement test at the end of the semester will show that more than 50% of the students in the sample will score 50% or better.

ii) Achievement tests and laboratory tests administered throughout the semester will show that more than 50% of the students in the sample will score 50% or better.

iii) Pre-test and Post-test scores on the Purdue Master Attitude Scale will show a significant positive change in the students' attitudes toward the study of Science.

E. <u>Limitations of the Study</u>

Vocational Science 103 was developed to meet the needs of a unique group of students. During the two years that have elapsed since the introduction of the alternative curriculum, it has become apparent that both student needs and course demands have changed markedly. Student needs have changed because the general ability level of these students has risen. The increasing interest in vocational education has encouraged students of a higher calibre to register in vocational courses. Course demands have changed because vocational technology is constantly changing. It should be clearly stated that this study was done with a certain group of students, at a certain period in time.

It is evident that, in general, the teacher - student relationship, as well as teacher expertise, is a large determining factor in the apparent success of any school course of study. This study made no effort to isolate any parameters involving these considerations.

Kildonan East Regional Secondary School normally experiences a vocational student attrition rate estimated to be in the order of 15% over a semester. The usual pattern sees the student who is performing poorly in his academic and vocational courses withdrawing from school. The effect on both achievement and attitude measures is one of skewing them positively. This study did not consider the student attrition factor.

FOOTNOTES

1. Bruner, J.S., The Process of Education, Harvard University Press, Cambridge, Mass., 1960, p. 10.

2. Hurd, P.D., New Directions in Teaching Secondary School Science, Rand McNally, Chicago, 1969, p. 6.

CHAPTER II

REVIEW OF LITERATURE

A. Introduction

The review of literature will include the following:

i) Characteristics of slow learners.

ii) Criteria for the construction of courses for the slow learner

iii) Basic strategies for evaluation of curricula.

B. The Slow Learner in Manitoba Schools

Experience in Secondary schools and an extensive review of literature indicates that Secondary schools fall far short in the satisfaction of the needs of students in every ability range.[1] In particular, they fall short with respect to the slow learner and the disadvantaged student.[2] There is no doubt that this is a serious problem, for as Ralph Tyler[3] points out, society can find constructive places for no more than 5% to 10% of its people who are unskilled and untutored. Tyler also indicates that this is a recent development when he says,

> The task of the high school is now recognized as that of educating a very large proportion of youth, including the 25% to 30% who have not been making substantial progress in earlier years.[4]

Professor Compton[5] of the University of Minnesota states that our schools are governed by middle class values and strives to project the heritage of middle class culture. Perhaps it is no coincidence that the largest number of slow learners come from the lower class.

The schools of Manitoba have felt the need to prepare appropriate academic courses for the slow learners. However, all too frequently the response has been to give this student a "watered down" version of a University Entrance program. This is inadequate and the students are "bright enough" to realize the essential falsity of this approach.

B. The Teacher of the Slow Learner

In the same address, Professor Compton[6] points out that the majority of educators come from the middle class and thus have some difficulty identifying with the problems of the slow learner. Personal experience indicates that the average teacher has some considerable difficulty understanding the disadvantaged child. A recent study by the National Committee on Employment of Youth had the following to say about the teacher of the disadvantaged child,

> Ideally, a teacher of the disadvantaged should have competence in his subject area, familiarity with modern methods of instruction, and be able to communicate with students. But understanding and ability to relate are more significant than either knowledge or pedagogical training and teaching methods.... Credentials, in fact, appear to be less important than committment.[7]

D. The Characteristics of the Slow Learner

Since, in Manitoba Secondary Schools, the vocational student is often a slow learner, it is appropriate to examine the characteristics of the slow learner. A study by Havighurst and Stiles characterizes these students as "alienated", and that for the following reasons:

> Such youth have been unsuccessful in meeting the standards set by society for them - standards of behaviour, of learning in school, of performance on the job. By the time they reach adolescence these boys and girls are visible as the "misfits" in the school.[8]

Robert Karlin,[9] writing in The Clearing House, presents a concise description of the slow learner in the following words:

> They cannot quite "keep up", usually do the poorest work in the normal classroom, although essentially normal in emotional, social, and physical development. Even in intellectual development, the slow learners are at the end or fringe of the normal group.[9]

In the same article, Karlin delineates specific characteristics. He writes as follows:

> ....other characteristics (of the slow learner) are:
>
> 1. He has a limited ability to evaluate materials.
> 2. He has limited powers of self direction.
> 3. He is slow to form associations between words and ideas.
> 4. He often fails to recognize familiar elements in new situations.
> 5. He learns slowly and forgets quickly.
> 6. He is generally unable to think critically.
> 7. He lacks originality.

8. He demonstrates a greater degree of character maladjustment than typical children.
9. He deals in "things" rather than in "thoughts".[10]

Ishmael Utley characterizes slow learners as follows:

1. He lives in a world of concrete objects and situations.
2. His memorization is often difficult and arduous.
3. He can solve problems if he sees the connections between the problem and the world in which he lives.
4. He cannot learn as fast as his peers.[11]

Experience at Kildonan East Regional Secondary School shows that many of the characteristics of the typical vocational student are those described above.

E. Criteria for a Vocational Science Course

The National Committee on Employment of Youth describes a vocational science curriculum as follows:

> ....The curriculum must emphasize the concrete rather than the abstract; the uses and applications rather than the rules, theory, and formulas. It must be person oriented, as well as craft or trade oriented, with a strong emphasis on behavioural objectives.[12]

A recent study by the Bureau of Occupational Educational Research, New York State, comments on both course characteristics and on ways in which slow learners should be treated. These comments are as follows:

1. Each session must be highly structured in order to turn students' minds and hands to activities which make them feel productive.

2. Text books should be used and should be similar in appearance to those of regular students to avoid sensitivity.

3. Home work assignments are not advisable. These students cannot discipline themselves to do it. Therefore, by giving such assignments, the opportunity is being given to "goof off" or fail.

4. Reading is torture to most students, so to be educated, life situations must be brought to them first hand through speakers, movies, and actual experience.

5. Actions regarding disciplining should be dealt with immediately and diligently. Firmness without severity and with understanding must be employed.[13]

F. <u>Criteria for a Vocational Science Course at Kildonan East Regional Secondary School</u>

The course criteria at Kildonan East Regional Secondary School were stated as follows:

1. It should not demand extensive verbal skills.
2. It should build up mathematical skills as they are required.
3. It should include the science concepts necessary for scientific literacy.
4. It should include the science concepts necessary for the support of the student's vocational area.
5. It should emphasize the practical aspects of science. That is, the science concepts should be learned by practical experimentation wherever possible.
6. It should emphasize the relatedness of science to the vocational areas.

G. Development of New Courses

Educational literature of the past decade is fairly lucid in describing the process of developing a new curriculum. Fletcher Watson, writing in The Science Teacher, describes the procedure quite simply:

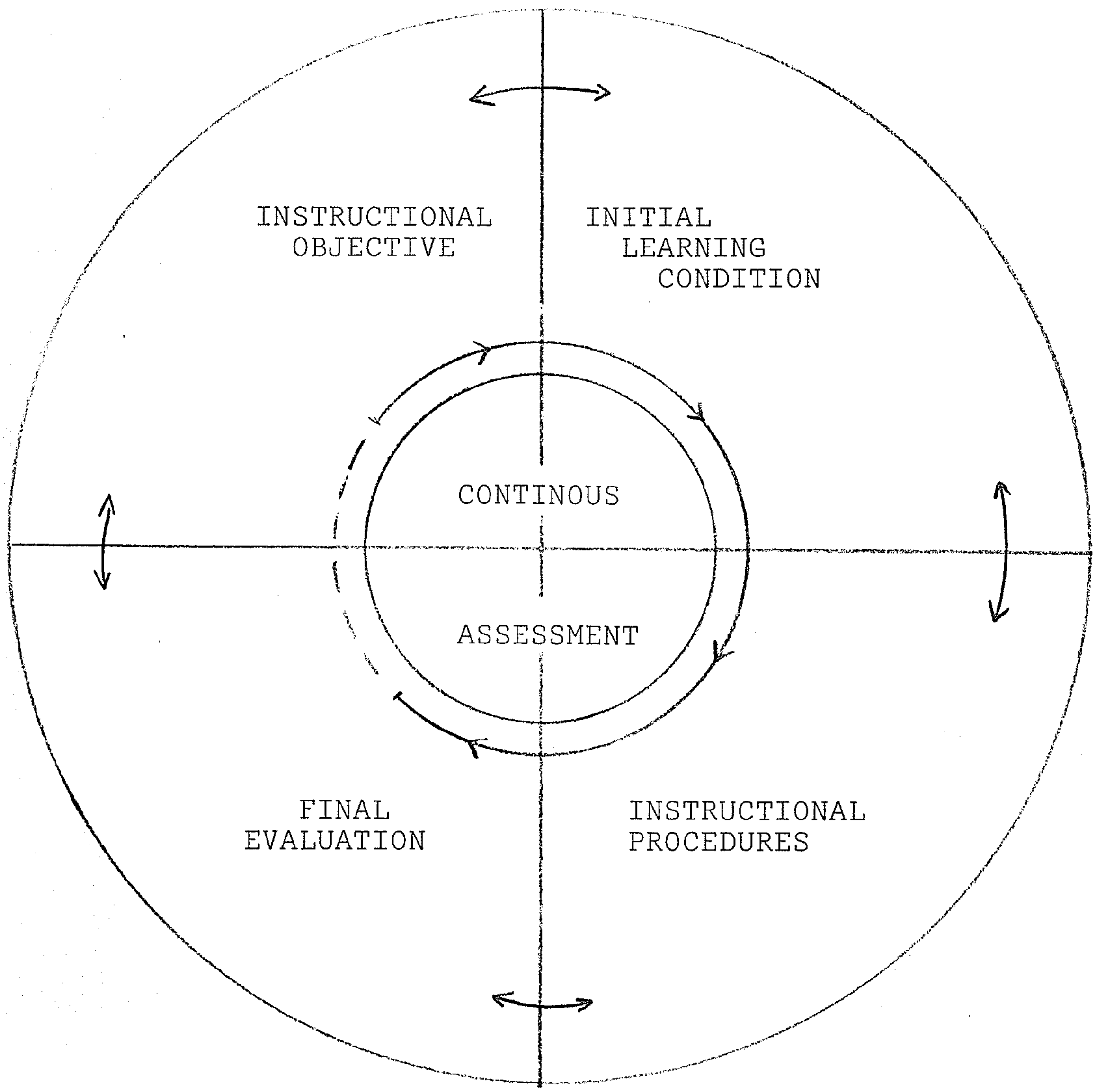
> The first task would be to establish roughly the general aims for a science program and the diversity of instructional materials needed by children of different abilities and interests. Then draft materials, probably in the form of units, ...These units would be tried on a small scale, then revised, tried again, and perhaps revised further.[14]

James W. Altman[15] approaches the issue of how one decides on a new curriculum from the viewpoint of educational objectives. He defines an objective as that which we want to achieve with the educational process and claims that the entire issue lies in determining the specific educational objectives.

R.L. Hedley and C.C. Wood,[16] in "A Report of an Interdisciplinary Approach to the Improvement of University Teaching", present an instructional model which can easily be adapted to a curriculum model.

FIGURE I

CURRICULUM MODEL



In using the curriculum model one begins with the upper left hand quadrant, instructional objectives, and proceeds clockwise to entering characteristics of students, instructional procedures, and final evaluation. Each quadrant contributes to the whole, and, thru continous assessment, is effectively inter-related to every other quadrant.

It seems then that there is general agreement among educators that curriculum development must begin with a series of clearly stated educational objectives.

It seems quite obvious that the next step in curriculum development is to draft course materials that are in step with the educational objectives. At this point the "course developer" becomes a judge, a judge of the particular course content and approaches which apparently fit the stated objectives.

H. Evaluation of New Courses

A properly developed curriculum, with its educational objectives and specific course outline, must be evaluated. The question, "Does the course accomplish what it has been set out to accomplish," must be answered.

i) Strategy Models

The literature on evaluation of curricula contains three clearly stated strategy models for evaluation. These models are as follows:

1. D.L. Stufflebeam[17] suggests that there are four types of data which could be collected, and therefore, four types of evaluation. Context evaluation aids in the selections of objectives by identifying problems. Input evaluation decides on the best plan to achieve stated objectives. Product evaluation assesses the goals and reasons for the obtained results. Process evaluation monitors the design.

2. R.E. Stake[18] states that there are two main ways of using descriptive data to evaluate a program: Finding contingencies among antecedents, transactions and outcomes, and finding congruence between intents and observations. All programs have intended characteristics which must be compared with the observed characteristics of the program in operation. The observation of both the intended and observed characteristics should be divided into three sub-categories: (1) Antecedents, any condition which exists before the program, (2) transactions, interactions which occur during the program, (3) outcomes. The data is congruent if what is intended is what is actually observed.

3. C.M. Lindvall and R.C. Cox[19] outline four major steps in planning an educational program: Defining the goals, plan, operation and assessment. The first requirement is that the goals of the program be well defined and clearly stated. Next a detailed plan of operations to achieve the suggested goals is necessary. The operation is the plan put into action. The main focus is on how successful the plan has been put into operation. Modifications to improve the implementation can be made. The final step is the assessment of the extent to which the goals have been met.

ii) Components of Evaluation

All three of the preceding models appear to use different words to express four major components necessary for a program's evaluation. These four components are as follows:

1. A statement of objectives.
2. A statement of methods for evaluating the obtained results.
3. A description of what the program should look like.
4. A comparison of item (3) with what the program is in actual operation.

Elliot Eisner, Stanford University, summarizes the basic strategy of course evaluation when he writes,

> If one has designed instructional materials for achieving highly specific outcomes the evaluation problem is straight-forward: One appraises the value of the material by the extent to which they achieve what they were designed to achieve.[20]

iii) Formative and Summative Evaluation

Michael Scriven[21] makes a useful distinction between "in-course" evaluation and "end-of-course" evaluation by using the words formative and summative evaluation. He notes that much evaluation in curriculum development is actually formative. That is, the evaluation data is fed back and is used to further refine the curriculum.

iv) Evaluation by Comparison

As has been pointed out, there is considerable agreement on general strategies for course evaluation. However, there exists some considerable difference of opinion on the practical considerations necessary for evaluation.

Often courses of study are evaluated by comparing them to other courses. Cronbach, writing in the Teachers College Record, expresses his opinion of this particular method when he writes,

> The aim to compare one course with another should not dominate plans for evaluation. Formally designed experiments, pitting one course against another, are rarely definitive enough to justify their cost. Differences between average test scores resulting from different courses are usually small relative to wide differences among and within classes taking the same course. At best, an experimenter never does more than compare the present version of one course with the present version of another.[22]

v) Summary

What, then, are the specific outcomes of a new course that should be evaluated?

Certainly the achievement of the students taking the course must be evaluated. That is, the question, "Does student achievement show that the course objectives have been met?", must be answered.

Robert Gagne is considering student achievement when he writes,

> ...a fairly straight forward method can be employed to test the appropriateness of a proposed curricular structure. This consists of designing and administering a test ...[23]

However, student achievement is not the only factor that must be examined in a program of curriculum evaluation. Another factor is student attitude. A successful course of studies will change student attitudes. The final report of The Callaway Gardens Conference on Building a Multi-Year, Multi-Disciplinary, High School Science Program, had this to say about attitudes:

> We should be concerned not only with content and processes of Science but with students' resultant attitudes toward learning. Too much concern for immediately measurable behavioural objectives could cause us to ignore things that might enable and encourage the student to continue learning on his own in the future.[24]

Lee Cronbach indicates that a curriculum evaluation should include the following:

1. Process studies.
2. Proficiency and attitude studies.
3. Follow-uo studies.[25]

The impact of the relevant literature also leads one to believe that an overall judgement of the appropriateness of the curriculum is also part of evaluation. Surely a qualified educator-scientist could judge whether the course is consistent with the best contemporary knowledge.

I Vocational Science Curriculum Studies

Recent literature records several research studies in which vocational science curricula were developed and evaluated. The Texas Education Agency, Austin, Texas, instituted a Coordinated Vocational-Academic Education Curriculum Project[26] in 1969. As one of its academic courses it had a science program which attempted to relate science with vocational areas. The evaluation measures included an achievement test, in which mastery over specific performance objectives was measured at 90%, and an attitudes to Science test. Both tests were administered as pre and post tests.

The Eastern Regional Institute, Syracuse, New York[27], made an evaluation of Science, A Process Approach, by measuring student achievement with respect to the behavioural objectives of the course. No control groups, in the traditional sense of statistical testing, were used. Pupil achievement ranged from 78% to 87%.

Both of the preceding programs were deemed successful.

FOOTNOTES

1. Hurd, P.D., New Directions in Teaching Secondary School Science, Rand McNally, Chicago, 1969, p. 6.

2. Ibid, p. 6.

3. Tyler, R.W.,"Changing Concepts in Educational Evaluation", in Tyler et al (Eds.), Persepectives of Curriculum Evaluation, Rand McNally, Chicago, 1967, p. 15.

4. Ibid, p. 15.

5. Compton, Beaulah Prof., Area Principal's Institute, University of Minnesota, 1963.

6. Ibid.

7. ____ National Committee on Employment of Youth, A Guide to the Development of Vocational Education Programs and Services for the Disadvantaged, National Committee on Employment of Youth, New York, 1969, p. 11. (ERIC ED 035 743)

8. Havighurst, R. J. and Stiles, L. J., "National Policy for Alienated Youth", Phi Delta Kappan, 1961.

9. Karlin, R., "Reading Skills for Slow Learners in Junior and Senior High Schools", The Clearing House, XXXV, pp. 280-4.

10. Ibid, p. 282.

11. Utley, Ishmael, "The Slow Learner in the Secondary School", Education, LXXXI, pp. 341-4.

12. ____ National Committee on Employment of Youth, A Guide to the Development of Vocational Education Programs and Services for the Disadvantaged, National Committee on Employment of Youth, New York, New York, 1969, p. 8. (ERIC ED 035 743)

13. ____ Bureau of Educational Research, New York State Education Department, Guided Occupational Training: A Vocational Work Experience for Intellectually Limited and Educationally Handicapped Students, Final Report, New York State Education Department, Albany, New York, 1969, pp. 36-37.(ERIC ED 034 042)

14. Watson, Fletcher, "Teaching Science to the Average Pupil", Science Teacher, 34, No. 3, p. 26.

15. Altman, James W., "A Behavioural View of Vocational-Technical Education", in Schaefer, C.J. et al (Eds), Vocational-Technical Education: A Prospectus for Change, College of Education, Northeastern University, Boston, 1967, p. 27.

16. Hedley, R.L. and Wood, C.C., Man U Teach, University of Manitoba Press, Winnipeg, Manitoba, January, 1974, p. 7.

17. Stufflebeam, D.L., "The Use of Experimental Design in Educational Evaluation", A paper presented at the annual meeting of the American Educational Research Association Annual Meeting, Minneapolis, Minn., 1970. (ERIC ED 045 706)

18. Stake, R.E., "Toward a Technology for the Evaluation of Educational Programs", in Tyler et al. (Eds.), Perspectives of Curriculum Evaluation, Rand McNally, Chicago, 1967, pp. 1-12.

19. Lindvall, C.M. and Cox, R.C., "Evaluation as a Tool in Curriculum Development: The IPI Evaluation Program", AERA monograph on Curriculum Evaluation, No. 5, Rand McNally, Chicago, 1970.

20. Eisner, Elliot W., "The Evaluation and Research of Curriculum Materials", A paper presented at the annual meeting of the American Educational Research Association, Minneapolis, Minnesota, 1970. (ERIC ED 041 946)

21. Scriven, Michael, "The Methodology of Evaluation", in Tyler et al (Eds.), Perspectives of Curriculum Evaluation, Rand McNally, Chicago, 1967, pp. 39-83.

22. Cronbach, L.J., "Course Improvement Thru Evaluation", Teachers' College Record, LXIV, pp. 672-83.

23. Gagne', Robert, "Curriculum Research and the Promotion of Learning", in Tyler et al (Eds.), Perspectives of Curriculum Evaluation, Rand McNally, Chicago, 1967, p. 29.

24. Florida State University, The Callaway Gardens Conference on Building a Multiyear, Multidisciplinary, High School Science Program, Final Report, Florida State University, Tallahassee, 1971. ERIC ED 068 295)

25. Cronbach, L.J., "Course Improvement Thru Evaluation"' Teachers' College Record, LXIV, pp. 672-83.

26. ____Education Service Center Region 1, CVAE (Coordinated Vocational-Academic Education), Academic Curriculum Project, Evaluation Report, Education Service Center Region 1, Edinburg, Texas, 1972. (ERIC ED 066 289)

27. Ritz, W.C., "Evaluation of Curriculum Installation: An Evaluation of a Two Year Installation of "Science-A Process Approach", Eastern Regional Institute for Education, Syracuse, New York, 1970. (ERIC ED 064 779)

CHAPTER III

COURSE DEVELOPMENT

A. Student Characteristics

Characteristics of the typical vocational student were identified by studying Guidance Department and Resource Department files, consulting teachers experienced in teaching vocational students, and perusing relevant literature. The student so identified may be described as follows:

i) As shown by Tables I and II he scores well below grade placement in both Reading and Mathematics.

ii) He portrays a limited interest and skill in dealing with abstractions and generalizations.

iii) He portrays a considerable interest in concrete activities and a corresponding ability in dealing with them.

iv) He portrays a limited interest in the study of academic subjects.

v) He often portrays an apparently retarded growth in personality and social adjustment patterns.

TABLE I

READING TEST, KILDONAN EAST REGIONAL SCHOOL
GRADE TEN, SEPTEMBER 1974, PERCENTILE RANK

Percentile Rank	Course 100 N = 72	Course 101 N = 74	Course 103 N = 66
1 - 10	1	6	13
11 - 20	5	8	11
21 - 30	11	19	11
31 - 40	5	9	9
41 - 50	7	20	9
51 - 60	5	4	6
61 - 70	9	6	6
71 - 80	14	1	1
81 - 90	10	9	0
91 - 100	5	2	0

Table I presents the results of a reading test that was given to Grade ten students at Kildonan East Regional Secondary School in September, 1974. The percentile rank distribution shows that students registered in the vocational courses (103) scored much lower in reading skills than students registered in other Grade ten courses (101, 100).

TABLE II

MATHEMATICS TEST, KILDONAN EAST REGIONAL SCHOOL
GRADE TEN, SEPTEMBER 1974 GRADE RANKING

Grade Rank	Course 100 N = 28 %	Course 101 N = 24 %	Course 103 N = 53 %
4	0	0	1.8
5	0	4.0	18.8
6	0	12.5	35.8
7	7.1	25.0	18.8
8	28.6	25.0	13.2
9	32.1	30.0	11.3
10	21.5	4.0	0
11	3.6	0	0
12	7.1	0	0

Table II presents the results of a Mathematics test that was given to Grade ten students at Kildonan East Regional Secondary School in September, 1974. The grade ranking shows that students registered in the vocational courses (103) place at generally lower grade levels in mathematics skills than students registered in other Grade ten courses (101, 100).

B. Course Criteria

After identifying the typical vocational student, several basic criteria were formulated which could act as guide posts in drafting Vocational Science 103. These criteria were as follows:

i) Since the vocational student scores well below grade placement in Reading, it will not demand extensive verbal and literary skills.

ii) Since the vocational student scores well below grade placement in Mathematics, it will not demand extensive Mathematics skills.

iii) Since the vocational student portrays an extensive interest in concrete activities, and a corresponding ability in dealing with these activities, it will teach Science concepts by practical experimentation, wherever possible.

iv) Since, in a Vocational High School, academic studies are, in fact, a support for vocational studies, it will include the Science concepts necessary for the support of the students' vocational areas. It will place a heavy emphasis on the related areas between Science and Vocational Studies.

v) Since all High School Science Courses have the impartation of scientific literacy as a general objective, it will include those concepts necessary for such literacy.

C. Course Development Procedure

After identifying the typical vocational student and formulating basic course criteria, actual course development was begun. The procedure was as follows:

i) School divisions, universities, and ministries of education were approached for information on vocational science courses. This approach yielded a limited amount of useful curriculum material.

ii) Each vocational instructor at Kildonan East Regional Secondary School was approached and asked to identify the Science concepts within his vocational area.

iii) Based upon the information gathered from the vocational instructors, a matrix relating Science concepts to vocational areas was constructed.

iv) An individual conference was held with each vocational instructor during which the Science Concept - Vocational Area matrix was presented and suggestions for additions and changes were entertained.

v) The suggestions were considered and a revised matrix was constructed.

vi) The Science concepts described on the matrix were divided into three horizontal levels based upon students' abilities and vocational course timing requirements. The first level was considered to be Vocational Science 103.

Table III is a course outline for Vocational Science 103 .

D. Instructional Objectives

A set of instructional objectives was prepared for Vocational Science 103 using a pattern suggested by Gronlund[1]. This pattern proceeds from a general instructional objective to several related specific learning outcomes. This pattern was particularly appealing in that it allowed the statement of desirable, but immeasurable, general objectives, in specific behavioural and measurable terms. The General Instructional Objectives and Specific Learning Outcomes are presented in Appendix "A".

E. Laboratory Outlines

Of the 88 Specific Learning Outcomes listed for Vocational Science 103, 33 were directly related to practical activities. A laboratory experiment of a particular format was prepared for each one of these Learning Outcomes.

The format used expresses each experiment as a problem, lists the materials needed, suggests an experimental design, and provides space and guidance in gathering and noting data. It is an appealing pattern in that it provides sufficient structure, yet allows each student to make his own conclusions.

The laboratory outlines for Vocational Science 103 are presented in Appendix "B".

TABLE III

COURSE OUTLINE VOCATIONAL SCIENCE 103
KILDONAN EAST REGIONAL SECONDARY SCHOOL

Chemistry	Mathematics	Physics
States of Matter	Measurement - Linear - Area - Volume - Mass	Temperature
Properties of Matter - Physical - Chemical	Scientific Notation	Phase Changes
Elements/ Compounds	Graphing	Heat Quantities
Conservation of Mass		Heat Exchange
		Heat Effects - Transfer - Expansion - Contraction

Table III is the course outline for Vocational Science as developed at Kildonan East Regional Secondary School.

F. Congruency of Vocational Science 103 With Course Criteria

Vocational Science 103 consists of a set of instructional objectives and a set of laboratory outlines. Both objectives and laboratory outlines were designed so as to be congruent with basic course criteria.

This congruency may be seen by examining the laboratory outlines on Measurement.

This section consists of the following experiments:

i) To measure the length, width, and height of rectangular blocks, and from this data calculate the volume.

ii) To measure the height and diameter of several cylindrically shaped blocks and from this data calculate the volume.

iii) To measure the volume of the cylinders used in the previous investigation by the displacement of water.

iv) To measure the volume of several irregularly shaped objects.

v) To determine the mass of several objects.

vi) To determine the mass of several liquids.

vii) To determine the masses of several different objects that have the same volume.

viii) To determine the mass and volume of several metal objects and to calcuoate the density of each.

ix) To determine the density of a liquid by measuring the masses of different volumes.

x) To determine the density of several liquids.

xi) To determine your understanding of densities and your ability to calculate the density of several materials.

A careful examination of the preceding laboratory outlines shows congruency with basic course criteria as described below:

i) They do not demand extensive verbal and literary skills.

ii) They do not demand extensive mathematics skills.

iii) They deal with concrete, practical activities.

iv) They carry a related emphasis on the area between Science and Vocations.

v) They involve concepts that are necessary for basic scientific literacy.

FOOTNOTES

1. Gronlund, Norman E., _Stating Behavioural Objectives for Classroom Instruction,_ Collier Macmillan, London, 1970, p. 7.

CHAPTER IV

RESEARCH DESIGN

A. The Problem

As was stated in Chapter I, this study has two components: Course development and course evaluation. Course development has already been detailed; course evaluation requires a statistical treatment and thus, a research design.

The research design was addressed to the following three hypotheses:

i) An achievement test at the end of the semester will show that more than 50% of the students in the sample will score 50% or better.

ii) Achievement tests and laboratory tests administered throughout the semester will show that more than 50% of the students in the sample will score 50% or better.

iii) Pre-test and Post-test scores on the Purdue Master Attitude Scale will show a significant positive change in the students' attitudes toward the study of Science.

B. Population and Sample

In any given semester, approximately 80 students from 10 different vocational areas register in Vocational Science 103. They are assigned arbitrarily to class groups of about 20 students and are usually assigned to different instructors.

During the semester in question, enrolment in Vocational Science 103 numbered 74 students in 4 class groups. For reasons of administrative convenience, 3 class groups, having 14, 18, and 22 students respectively, and assigned to 2 different instructors, were selected for the study.

C. Research Procedure

i) Achievement Measured at Semester End

The degree to which the subjects in the sample met the total course objectives was measured by a 36 item short answer test prepared by the writer and administered at the end of the instruction period.

Content validity was assured by consulting with 2 collegues, one, the Head of the Department of Science at Kildonan East Regional Secondary School, the other, an instructor in Science at the same institution.

Face validity and general readability at approximately the grade 8 level, was verified by an instructor in the Faculty of Education, University of Manitoba.

The semester end student achievement test was prepared for a 50 minute class period and thus included only some 90% of the specific learning outcomes that could be measured by a written test.

ii) Achievement Measured Throughout the Semester

The degree to which the subjects in the sample met course objectives from week to week throughout the semester was measured by teacher made achievement tests and by teacher records of students' laboratory performance.

iii)Attitudes

Student attitude toward the study of Science was measured by Form A of the Purdue Master Attitude Scale. All subjects were given Form A of the attitude test, both as a pre-test and a post-test.

Form A was used both as the pre-test and the post-test because the wording of Form B was judged to be unnecessarily difficult and the time period that elapsed between the 2 testing periods was considered long enough to preclude any memory effects.

D. Statistical Procedures

i) Semester End Achievement

End of semester achievement tests were scored using the key in Appendix "D".

An item analysis of each student's answer sheet was carried out to determine how many students in each group answered each item correctly. This analysis is expressed by a matrix as well as by a graph of item number against the percentage of students having the correct answer.

The number of students who scored 50% or better was determined.

In order to summarize achievement test data, calculations of percentage marks, arithmetical means, and standard deviations, as well as a graphical plot of mark distributions, was done for each class group.

ii) Achievement Throughout the Semester

Achievement of course objectives throughout the semester was reported by recording the teacher's final test mark for each student. These test marks were cumulative marks based on weekly written tests.

Achievement of practical objectives throughout the semester was reported by recording the teacher's total laboratory mark for each student.

iii) Attitude

Each attitude test was scored using the weighted scale values published by Remners. The arithmetical mean of each set of pre-test and post-test scores of each class group was calculated.

The "t" test for dependent samples was applied to the pre-test and post-test scores of each group in order to determine the significance of any differences in the means.

All statistical data and analyses are reported in Chapter V.

CHAPTER V

DATA AND ANALYSIS OF DATA

A. Identification of Statistical Groupings

The subjects in this study were 54 students divided in 3 class groups of 14, 18, and 22 members respectively. For the purposes of this chapter the groups will be referred to as groups A, B, and C.

Groups A and B were instructed by one teacher; group C by a second teacher.

B. Data and Analysis

The following 13 pages are devoted to the presentation of statistical data and analysis.

i) Tables IV to VIII and Figures II to V refer to end of semester achievement tests.

ii) Tables IX and X refer to achievement tests and laboratory performance throughout the semester.

iii) Tables XI and XII refer to attitude tests.

TABLE IV

SEMESTER END ACHIEVEMENT TEST, RAW DATA
MAXIMUM SCORE = 36

Group A N = 18		Group B N = 14		Group C N = 22	
Raw Score	%	Raw Score	%	Raw Score	%
14	39	11	30	7	19
16.5	46	12.5	35	15	42
16.5	46	14.5	40	18	50
18.5	51	16.5	46	19	53
20	56	17	47	19.5	54
21	58	18	50	19.5	54
21.5	60	19.5	54	21	58
21.5	60	22.5	63	21.5	60
22.5	63	22.5	63	25	69
23	64	23	64	25	69
23	64	23	64	26.5	74
23.5	65	23.5	65	27	75
25	69	27	75	27	75
25	69	28.5	79	28	78
24	67			28	78
26	72			28	78
28	78			29.5	82
28	78			31	86
				31.5	88
				30	83
				32	89
				32	89

Table IV presents the raw data of the semester end achievement test. Scores range from a low of 19% in Group C to a high of 89% in Group C.

TABLE V

SEMESTER END ACHIEVEMENT TEST, ITEM ANALYSIS

Item Number	% of Students With Correct Answer			Item Number	% of Students With Correct Answer		
	Group A N = 18	Group B N = 14	Group C N = 22		Group A N = 18	Group B N = 14	Group C N = 22
1	95	100	86	19	44	21	73
2	50	50	31	20	44	7	82
3	89	57	50	21	21	21	64
4	83	57	55	22	39	50	73
5	89	72	77	23	11	14	77
6	67	64	82	24	95	79	77
7	78	42	77	25	83	79	73
8	95	93	91	26	83	72	68
9	44	36	68	27	78	57	64
10	83	72	68	28	83	86	96
11	32	36	50	29	44	57	73
12	67	36	59	30	39	50	86
13	61	86	41	31	78	64	77
14	67	79	86	32	61	64	41
15	72	93	86	33	6	14	41
16	78	93	91	34	32	57	55
17	72	50	86	35	32	7	50
18	50	50	77	36	56	29	64

Table V indicates the % of students in each group who achieved the correct answer for each particular item.

TABLE VI

SEMESTER END ACHIEVEMENT TEST, ITEM ANALYSIS
TOTAL SAMPLE

Item Number	% of Students With Correct Answer N = 54	Item Number	% of Students With Correct Answer N = 54
1	93	19	50
2	41	20	50
3	65	21	39
4	65	22	56
5	80	23	39
6	72	24	83
7	69	25	78
8	93	26	74
9	52	27	67
10	74	28	89
11	41	29	59
12	56	30	61
13	59	31	74
14	78	32	54
15	83	33	22
16	87	34	48
17	72	35	52
18	61	36	52

Table VI indicates that 30 of the 36 test items were answered correctly by at least 50% of the students in the sample. Stated differently, 83% of the test items were answered correctly by at least 50% of the students.

TABLE VII

SEMESTER END ACHIEVEMENT TEST, SUMMARY
NUMBER AND PERCENTAGE OF STUDENTS SCORING MORE THAN 50%

	Number of Students	Percentage of N
Group A N = 18	15	83.33
Group B N = 14	9	64.28
Group C N = 22	20	90.91
Total Sample N = 54	44	81.47

Table VII indicates that 81.47% of all students in the sample scored at least 50% on the semester end achievement test. Groups A and B did not receive instruction in scientific notation, an area upon which 4 test items were based. This explains, in part, the lower performance in these two groups.

TABLE VIII

SEMESTER END ACHIEVEMENT TEST: SUMMARY
MEAN AND STANDARD DEVIATION

	Group A N = 18	Group B N = 14	Group C N = 22
Mean	61%	55%	69%
Standard Deviation	3.78	5.05	6.75

Table VIII presents the arithmetic mean and the standard deviation of each group in the semester end achievement test.

FIGURE II

GRAPH OF ITEM NUMBER AGAINST PERCENTAGE OF STUDENTS HAVING THE CORRECT ANSWER
GROUP A

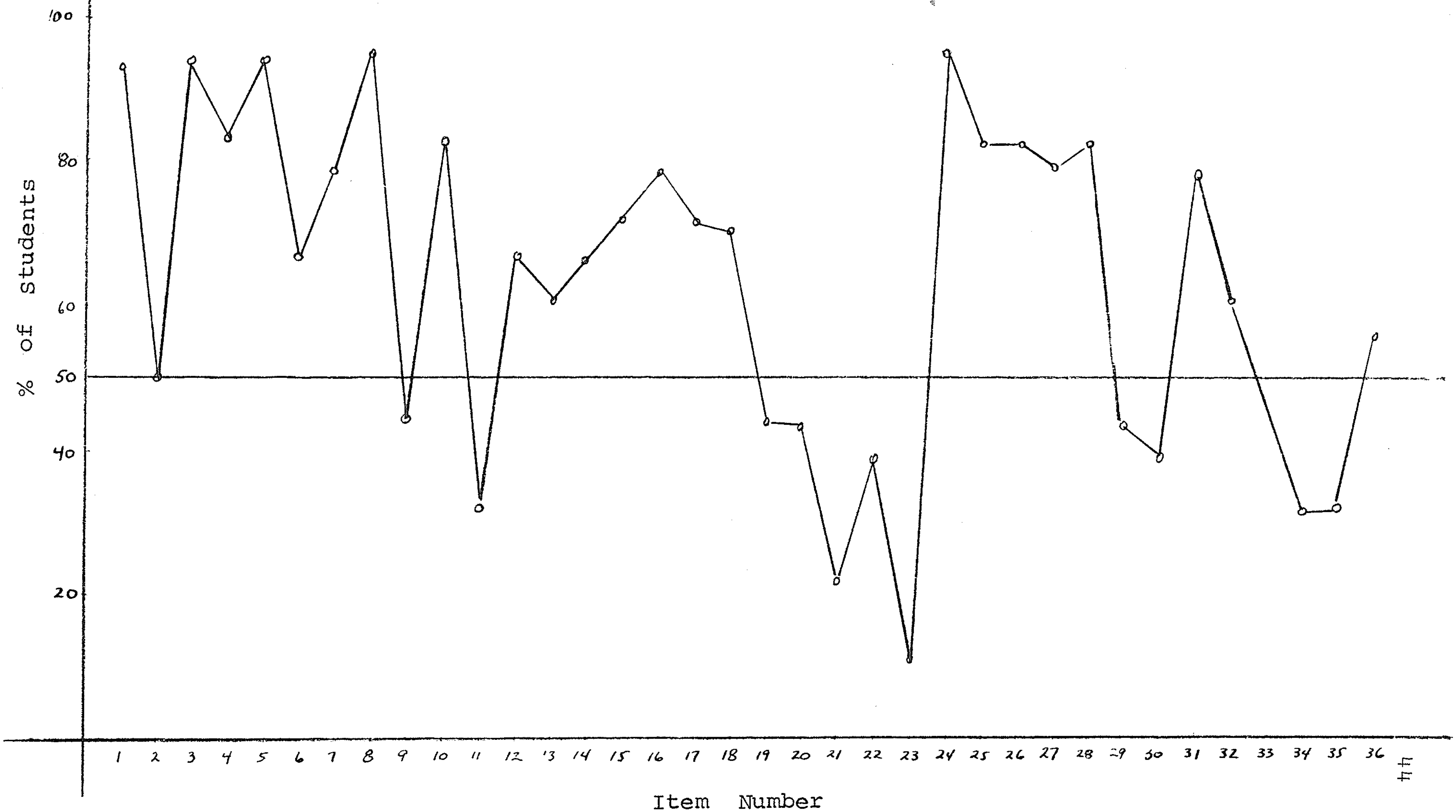


FIGURE III

GRAPH OF ITEM NUMBER AGAINST PERCENTAGE OF STUDENTS HAVING THE CORRECT ANSWER
GROUP B

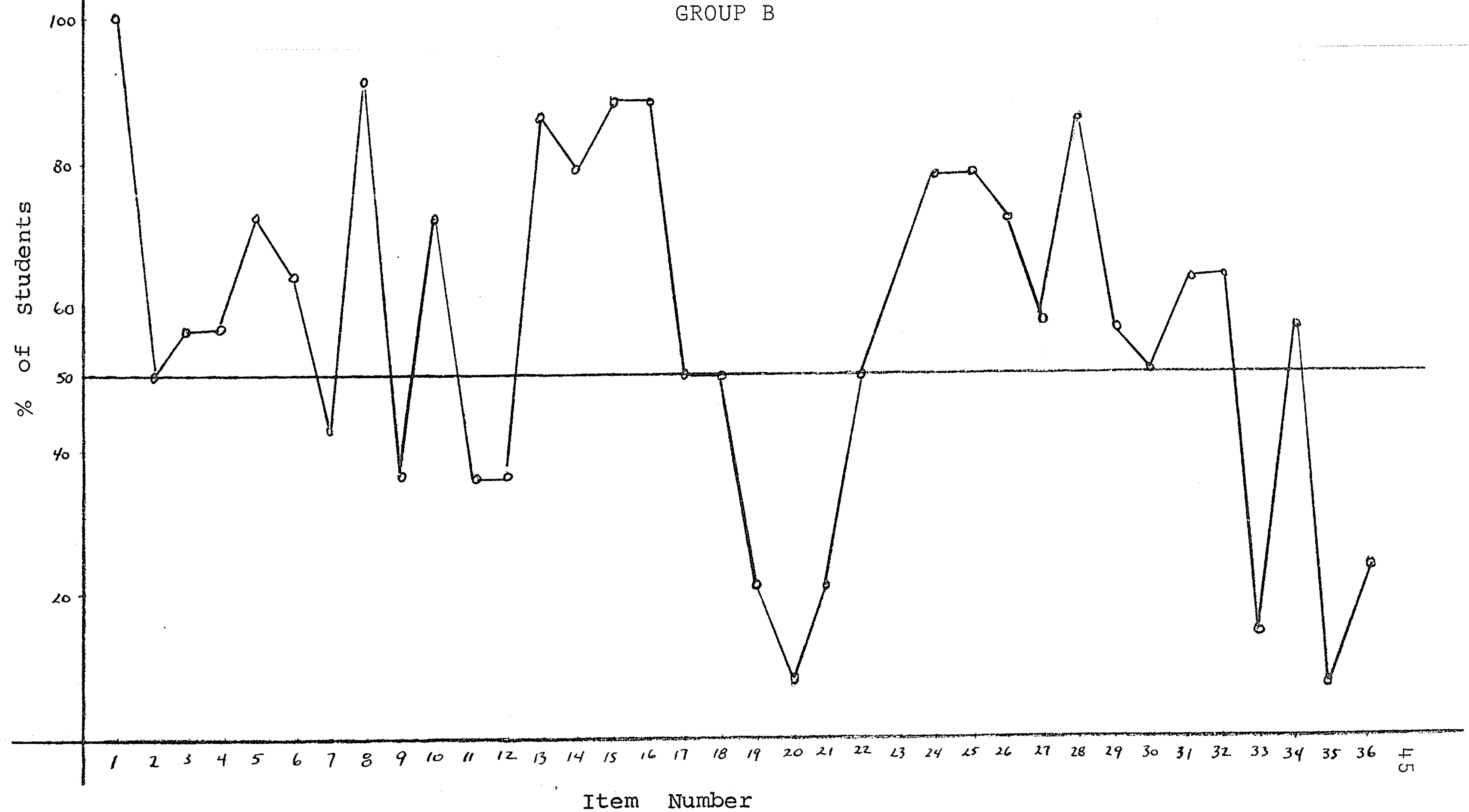


FIGURE IV

GRAPH OF ITEM NUMBER AGAINST PERCENTAGE OF STUDENTS HAVING THE CORRECT ANSWER
GROUP C

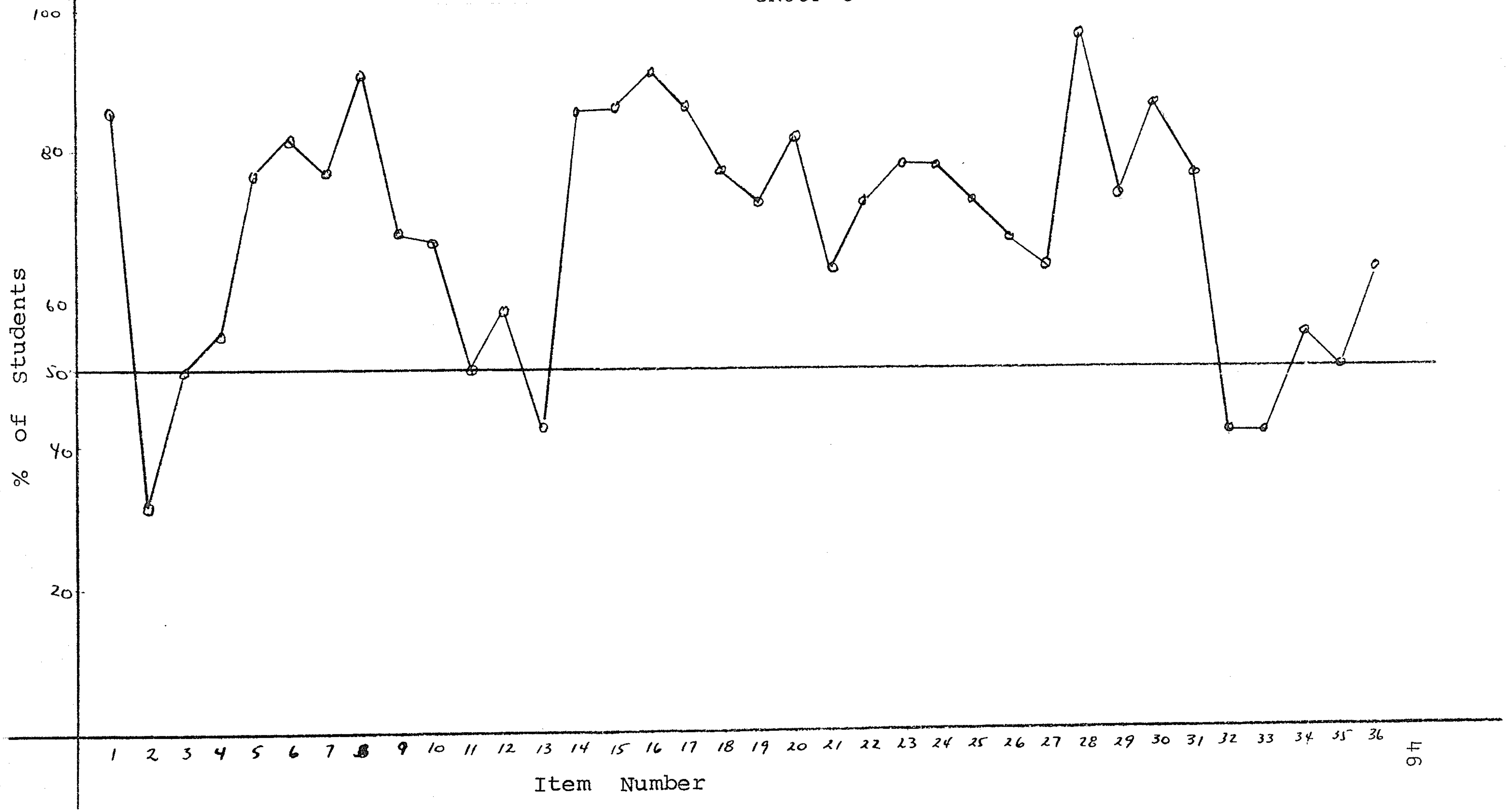


FIGURE V

GRAPHICAL DISTRIBUTION OF SEMESTER END ACHIEVEMENT TEST MARKS

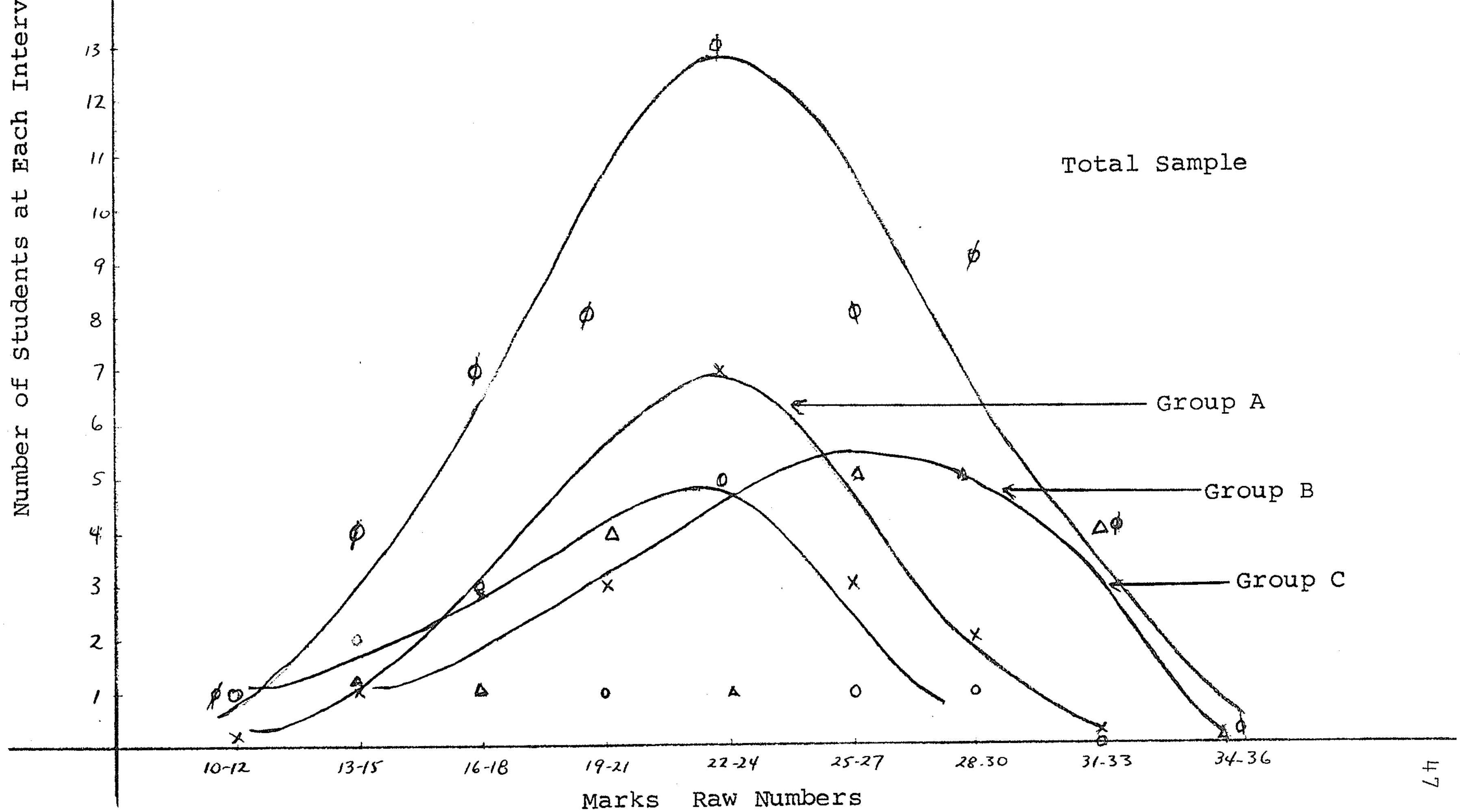


TABLE IX

ACHIEVEMENT TESTS THROUGHOUT THE SEMESTER
TEACHER CONSTRUCTED

Group A N = 18 %	Group B N = 14 %	Group C N = 22 %
35	60	22
55	62	36
59	63	46
60	64	57
63	65	58
63	65	60
65	67	62
66	68	64
68	75	71
68	76	73
73	77	73
74	78	75
75	78	77
75	91	79
76		80
80		81
82		82
86		83
		84
		86
		87
		92
Mean = 70.6	Mean = 67.9	Mean = 69.4

Table IX presents the average of all teacher constructed achievement tests written by each student in the sample during the entire semester. The table indicates that 94% of Group A, 100% of Group B, and 86.3% of Group C, scored 50% or better.

TABLE X

LABORATORY PERFORMANCE THROUGHOUT THE SEMESTER
TEACHER RECORDS

Group A N = 18 %	Group B N = 14 %	Group C N = 22 %
52	56	50
56	62	50
61	64	50
67	68	57
67	69	60
67	70	60
67	70	67
69	71	67
71	73	67
71	74	67
71	76	67
74	79	67
75	80	70
75	95	73
77		73
78		77
85		80
86		80
		80
		87
		93
		93

Table X presents the average of each student's laboratory performance during the entire semester. The individual marks were calculated from the instructors' records of students' laboratory performance. No students scored less than 50%.

TABLE XI

ATTITUDES TO THE STUDY OF SCIENCE, PURDUE MASTER ATTITUDE SCALE, WEIGHTED SCORES

Group A				Group B				Group C			
Pre - Test N = 20		Post - Test N = 16		Pre - Test N = 19		Post - Test N = 14		Pre - Test N = 27		Post - Test N =19	
2.4	6.0	1.0	8.1	2.85	6.25	4.7	7.7	2.4	6.0	1.0	7.7
2.4	6.0	5.35	8.1	3.1	6.85	6.0	7.9	2.4	6.0	4.7	8.1
3.25	6.25	5.75	8.1	3.1	7.05	6.0	8.1	2.85	6.0	5.35	8.1
4.7	6.85	6.0	8.3	3.25	7.7	6.0	8.3	3.1	6.0	5.75	8.1
5.5	6.85	6.25	8.5	3.35	7.7	6.5	8.45	3.1	6.25	6.0	8.1
5.5	7.7	6.5	8.5	3.35	7.9	7.25	8.7	3.25	6.25	6.0	8.1
5.5	7.7	7.05	8.7	5.5	8.1	7.7	8.7	3.25	6.85	6.0	8.3
5.35	7.7	8.1	8.9	5.5	8.5			3.35	6.85	6.0	8.3
5.75	7.7			5.5				3.35	6.85	6.25	8.45
6.0				5.5				4.7	7.05	6.5	8.5
6.0				5.5				5.35	7.7	6.5	8.5
								5.5	7.7	7.9	8.7
								5.5	7.7	7.05	8.7
								5.5	7.7	7.25	8.7
								5.5	7.7	7.7	8.9
								5.5	7.7		
								5.5	7.7		
								5.5	7.9		
								5.5	8.1		
								5.75	8.5		

TABLE XII

ATTITUDES TO THE STUDY OF SCIENCE, PURDUE MASTER ATTITUDE SCALE, SUMMARY

	Group A	Group B	Group C
Pre - Test Mean	5.76	5.61	7.14
Post - Test Mean	7.41	7.29	7.84
t - Test for Significance at the 0.05 Level	Significant	Significant	Significant

Table XII presents the pre-test and post-test means of each class group on the Purdue Master Attitude Scale. The table indicates that the students' attitudes to the study of Science showed a significant positive change, at the 0.05 level of significance, during the period of instruction.

CHAPTER VI

CONCLUSIONS

A. Purpose of the Study

The purpose of this study was to describe the development and evaluate the effectiveness of Vocational Science 103. Course development was treated descriptively and was presented in Chapter III; Course evaluation was treated statistically and was presented in Chapters IV and V.

B. Hypotheses

The evaluation of Vocational Science 103 was represented by 3 hypotheses. They were stated as follows:

i) An achievement test at the end of the semester will show that more than 50% of the students in the sample will score 50% or better.

ii) Achievement tests and laboratory tests administered throughout the semester will show that more than 50% of the students in the sample will score 50% or better.

iii) Pre-test and Post-test scores on the Purdue Master Attitude Scale will show a significant positive change in the students' attitudes toward the study of Science.

C. Conclusions and Discussion

The statistical analysis of all relevant data supported all 3 hypotheses. Specifically stated, the statistical analysis showed that,

i) More than 50% of the students in the sample scored 50% or better on the semester end achievement test.

ii) More than 50% of the students in the sample scored 50% or better on both the achievement tests and laboratory tests administered throughout the semester.

iii) The students in the sample showed a significant positive change, at the 0.05 level of significance, in their attitudes toward the study of Science.

The analysis of all student achievement data, in terms of both written and practical performance, indicates that the instructional objectives were satisfied at a much higher level than the traditional 50% "pass" level.

It is evident that Vocational Science 103 was an effective and satisfactory Science course for vocational students at Kildonan East Regional Secondary School, during the period of this study.

D. Success of Vocational Science 103

Vocational Science 103 is a Science course designed specifically for vocational students. This study clearly indicates that it is a highly successful course for this particular group of students. It now seems evident that the aspects dictating its success are its practical nature, its limited literary academic content, and its high degree of structure.

Further curriculum development in vocational science, particularly at the 203 and 303 levels, is very necessary. One would hope that all further development in this area will pay due regard and attention to the basic requirements of the vocational student.

APPENDIX A

OBJECTIVES FOR SCIENCE 103

GENERAL INSTRUCTIONAL OBJECTIVES	SPECIFIC LEARNING OUTCOMES
Knows the three states of matter.	Lists the distinguishing properties of the three states of matter.
	Demonstrates, in the laboratory, how these properties apply to each of the three states.
	Identifies the state of the various materials in his vocational area.
Understands what a physical property is.	Determines the malleability and ductility of some shop metals.
	Determines the viscosity of several different grades of oil.
	Determines the elastic constant of several different kinds of wire.
	Compares the solubility of several different solids in a liquid.
	Recognizes the factor that makes a factor physical.
	Lists a set of physical properties.
Understands what a chemical property is.	Performs several experiments in which materials are changed chemically.
	Recognizes the factor that makes a property chemical.
	Lists a set of chemical properties.
	Classifies properties as either physical or chemical.
	Lists sets of physical and chemical properties in his vocational area.

GENERAL INSTRUCTIONAL OBJECTIVES	SPECIFIC LEARNING OUTCOMES
Uses a metric rule correctly and accurately.	Measures one dimension accurately and to the correct number of significant figures. Measures two dimensions accurately and to the correct number of significant figures. Measures 3 dimensions accurately and to the correct number of significant figures.
Knows the relationship between one, two, and three dimensions.	Calculates areas of rectangular shop materials accurately. Calculates volumes of rectangular shop materials accurately.
Uses a graduated cylinder correctly and accurately.	Reads any graduate accurately and to the correct number of significant figures. Measures the volume of several irregularly shaped solids accurately.
Uses a balance correctly and accurately.	Determines the mass of various shop solids and liquids. Reads the balance to the proper number of significant figures.
Understands the relationship between mass, volume, and density.	Determines accurately the density of solids. Determines accurately the density of liquids. States the definition of density.

GENERAL INSTRUCTIONAL OBJECTIVES	SPECIFIC LEARNING OUTCOMES
	Calculates the mass, volume, or density of a solid or a liquid from the formula for density, given any two of the variables.
Understands scientific notation.	Converts standard notation to scientific notation.
	Converts scientific notation to standard notation.
	Recognizes the usefulness of scientific notation.
	Calculates multiplication and division problems using scientific notation.
	Expresses shop numbers in scientific notation.
Knows how to graph a set of linear data.	Determines appropriate scales and axes.
	Plots ordered pairs on a graph.
	Draws a graph.
	Labels axes.
	Determines slopes.
	Extrapolates graphs.
	Interpolates graphs.
	Generates his own data and draws a graph of this data.
	Interprets linear graphs taken from his vocational subject area.

GENERAL INSTRUCTIONAL OBJECTIVES	SPECIFIC LEARNING OUTCOMES
Understands the meaning of temperature.	Determines the temperature of various liquids and solids from his vocational area with both a Fahrenheit and a Centigrade thermometer.
	Draws a conversion graph of Fahrenheit and Centigrade temperatures.
	Graphs the cooling curve for water from just below the boiling point to room temperature.
	Graphs to cooling curve for some other liquid from just below the boiling point to room temperature.
	Restates the definition of temperature.
	Calibrates an unmarked thermometer.
Comprehends the meaning and cause of phase changes.	Draws a cooling curve for water from room temperature to below freezing.
	Identifies the freezing point from the cooling curve.
	Draws a heating curve for water from room temperature to the boiling point.
	Identifies the boiling point from the heating curve.
	Lists four different types of phase changes.
	Defines generally what a phase change is.
	Identifies the relationship between heat loss or gain with a phase change.

GENERAL INSTRUCTIONAL OBJECTIVES	SPECIFIC LEARNING OUTCOMES
	Lists several phase changes from his vocational subject area.
Understands the distinction between heat and temperature.	Measures the temperature change of a given quantity of water when different amounts of the same metal at the same temperature are placed into it.
	Identifies a distinction between heat and temperature.
	Measures the temperature change of a given quantity of water when the same masses of different metals at the same temperature are placed into it.
	States a definition of heat.
	Lists the factors that determine the amount of heat retained by an object.
Knows the laws of heat exchange.	Determines the direction in which heat flows.
	Calculates the amount of heat gained or lost by a given solid or liquid.
	Lists specific examples of heat loss or heat gain from the vocational subject areas.
	Determines the law of conservation of heat for solids in liquids, and liquids in liquids.
	Applies the law of heat exchange, quantitatively, to examples from the vocational subject areas.
	Defines the units "Calories" and "BTU's".

GENERAL INSTRUCTIONAL OBJECTIVES	SPECIFIC LEARNING OUTCOMES
Knows how heat may be transferred.	Demonstrates, by experiment, how heat may be transferred by conduction, convection, and radiation.
	Determines the heat constant of several shop materials.
	Defines the three methods of heat transfer.
	Lists examples of heat transfer in the vocational subject areas.
Understands the effect of heat in expansion.	Measures the expansion of several solids, liquids, and gases.
	Lists the factors that determine the expansion of solids, liquids, and gases.
	Explains the molecular conception of expansion.
	Applies this explanation of expansion to examples from the vocational subject areas.

APPENDIX B

SCIENCE 103

Measurement | Volume 1 | Investigation 1

Problem: To measure the length, width and height of rectangular wood blocks, and from this data calculate the volume.

Materials: Assorted wood blocks, cut accurately in rectangular form, metric rule.

Experimental Design: Measure the length, width and height of each block to the nearest centimeter. Identify each block by the indicated number and write the length, width and height on the data chart.

Calculate the volume of each block in cubic centimeters.

e.g. Block 1 - length = 4 cm
width = 2 cm
height = 5 cm

Volume = length x width x height
= 4 cm x 2 cm x 5 cm = 40 cu cm

Data:

Block No.	Length	Width	Height	Volume

Questions:

1. A rectangular block has a length of 12 cm, a width of 5 cm, and a height of 3 cm. Calculate the volume of the block.

2. A rectangular block has a length of 8.1 cm, a width of 3.2 cm, and a height of 2.1 cm. Calculate its volume.

3. A block shaped like a cube has sides of 5 cm. Calculate the volume of the cube.

SCIENCE 103

Measurement | Volume 2 | Investigation 2

Problem: To measure the height and diameter of several cylindrically shaped blocks and from this data calculate the volume.

Materials: Assorted solid cylinders machined accurately to cylindrical form, metric rules, calipers.

Experimental Design: Measure the diameter and height of each cylinder to the nearest centimeter. Identify each block by the indicated number and record the diameter and height on the data chart.

Calculate the radius of each cylinder by dividing the diameter by 2. Calculate the volume of each cylinder in cubic centimeters by using the following equation:

Volume = 3.14 x radius x radius x height

e.g. Cylinder 1 - diameter = 6 cm
height = 5 cm

$$\text{radius} = \frac{\text{diameter}}{2} = \frac{6}{2} = 3 \text{ cm}$$

$$\text{volume} = 3.14 \times 3 \text{ cm} \times 3 \text{ cm} \times 5 \text{ cm} = 141.3 \text{ cu cm}$$

Data:

Cylinder No.	Diameter	Radius	Volume

Questions:

1. A cylinder has a diameter of 4 cm and a height of 7 cm. Calculate its volume.

2. A cylinder has a height of 12 cm and a radius of 3 cm. Calculate its volume.

3. A cylinder has a radius of 2.1 cm and a height of 5.2 cm. Calculate its volume.

SCIENCE 103

Measurement | Volume 3 | Investigation 3

Problem: To measure the volume of the cylinders used in investigation 2 by the displacement of water.

Materials: 100 ml graduated cylinder, cylinders used in investigation 2, water.

Experimental Design: Determine the volume of each cylinder by carefully lowering each cylinder in turn into the graduated cylinder half filled with water and reading the difference in water level before and after.

Enter this volume in milliliters on the data chart.

Compare this volume to the volume you calculated for the same cylinders in investigation 2.

Data:

Cylinder No.	Volume Investigation 2	Volume Investigation 3

Questions:

1. What is the relationship between a milliliter and a cubic centimeter?

2. In the graduated cylinder at the left, what is the volume of the water?

3. You have a volume of 20 cubic centimeters of water in a graduated cylinder. When a certain volume of sand is added to the cylinder, the water level rises to 25 cubic centimeters. What is the volume of the sand in cubic centimeters? What is the volume of the sand in milliliters?

SCIENCE 103

Measurement | Volume 4 | Investigation 4

Problem: To measure the volume of several irregularly shaped objects.

Materials: 100 ml graduated cylinder, dissecting pin, various objects of irregular shape.

Experimental Design: Fill the graduated cylinder to the 50 ml mark.

Take one of the objects you have been given and carefully lower it into the water till it is completely submerged. If the object floats, use the dissecting pin to push it into the water.

Read the graduate and calculate the volume of the object. Enter this volume on the data chart.

Repeat this procedure with each of the objects and enter your volume figures on the data chart.

Data:

Object	Volume	Object	Volume

SCIENCE 103

Measurement | Mass I | Investigation 5

Problem: To determine the mass (weight) of several objects.

Materials: Balance, various objects from the vocational areas.

Experimental Design: Place the balance on a level table and adjust to the zero point.

Determine the mass (weight) in grams of each object with the balance.

Record the mass of each object on the data chart.

Data:

Object	Mass	Object	Mass

Questions:

1. How accurately does the balance measure the mass of an object?

SCIENCE 103

Measurement | Mass II | Investigation 6

Problem: To determine the mass (weight) of several liquids.

Materials: Balance, 25 ml graduated cylinder, antifreeze, motor oil, gear oil, paint.

Experimental Design: Determine the mass of the empty graduated cylinder. Record this mass on the data chart.

Fill the graduated cylinder with antifreeze to the 25 ml mark. Determine the mass of the antifreeze and the graduated cylinder and record this mass on the data chart.

Follow the same procedure with the other liquids.

Examine your data chart. For each liquid, determine the mass of the liquid alone, by subtracting the mass of the empty cylinder from the mass of the cylinder and the liquid contents. Record this mass on the data chart.

Determine the mass per milliliter of each liquid you have used and record this value on the data chart.

Data:

Liquid	Mass of Empty Cylinder	Mass of Cylinder And Liquid	Mass of Liquid	Mass per Milliliter

SCIENCE 103

Measurement — Mass III — Investigation 7

Problem: To determine the masses of several different objects that have the same volume.

Materials: Balance, cylinders of different materials but equal volumes, 100 ml graduated cylinder.

Experimental Design: Determine the mass in grams of each cylinder with the balance. Record the masses on the data chart.

Determine the volume of each cylinder by the displacement of water in the graduated cylinder. Express these volumes in cubic centimeters and record them on the data chart.

Examine your chart and calculate the mass per cubic centimeter of each cylinder.

Data:

Cylinder No.	Mass	Volume	Mass Per Cubic Centimeter

SCIENCE 103

Measurement | Density I | Investigation 8

Problem: To determine the mass and volume of several metal objects and to calculate the density of each.

Materials: Several different kinds and sizes of metals, overflow can and/or 100 ml graduated cylinder, balance

Experimental Design: By using either the overflow can or the graduated cylinder, determine the volume of each metal object. Express this volume in cubic centimeters and record them on the data chart.

By using the balance, determine the mass of each metal object. Record the masses on the data chart.

Calculate the ratio of mass to volume for each object. This ratio is called the density and, in this investigation, is expressed in grams/cubic centimeters.

$$\text{Density} = \frac{\text{mass}}{\text{Volume}} \quad \text{or} \quad D = \frac{M}{V}$$

Data:

Metal	Mass	Volume	Density	Accepted Value For Density *
Copper				8.9 g/cm^3
Aluminum				2.7 g/cm^3
Steel				7.5 g/cm^3
Brass				8.5 g/cm^3

Questions:

1. What are the units for expressing density?
2. Why is a density measurement more important than just mass or volume?
3. How do your values for density compare with the accepted values? Suggest some reasons for any large differences.
4. How can density be used to determine the purity of metals?
5. What are some reasons why the density of metals may be important in industry?

SCIENCE 103

Measurement | Density II | Investigation 9

Problem: To determine the density of a liquid by measuring the masses of different volumes.

Materials: 50 ml graduated cylinder, balance, a liquid such as rubbing alcohol.

Experimental Design: By using a graduated cylinder and a balance, determine the mass of 5 ml, 10 ml, 15 ml, 20 ml, 25 ml, 30 ml, and 35 ml of the liquid provided. Record the mass of each of these volumes on the data chart.

Calculate the density of the liquid for each of the mass-volume sets.

Draw a graph of your mass-volume results. Place the volumes on the horizontal axis and the masses on the vertical axis.

Use the graph to calculate the density of the liquid you used.

Data:

Mass	Volume	Density
	5 ml	
	10 ml	
	15 ml	
	20 ml	
	25 ml	
	30 ml	
	35 ml	

Questions:

1. How does the graph result for density compare to the data chart results?
2. When the volume of the liquid was doubled, what happened to the mass?
3. What kind of a proportion is this?
4. From your graph, what would the mass of 40 ml of liquid be?

SCIENCE 103

Measurement | Density III | Investigation 10

Problem: To determine the density of several liquids.

Materials: 25 ml graduated cylinder, balance, several liquids such as alcohol, antifreeze and oil.

Experimental Design: By using the graduated cylinder and a balance, determine the mass of 10 ml of each liquid.

Record the mass and the volume for each liquid on the data chart.

Calculate the density for each liquid and record on the data chart.

Data:

Liquid	Mass	Volume	Density

Questions:

1. What units are used for expressing density?
2. The density of water is 1 g/cm^3. Which liquids in this investigation have a density greater than water? Less than water?
3. Suggest ways in which the density of liquids might be important in industry.

SCIENCE 103

Measurement | Density Test | Investigation 11

Problem: To determine your understanding of densities and your ability to calculate the density of several materials.

Materials:

Experimental Design: Determine the density of the solid and the liquid given to you by the instructor.

Show all calculations and units.

Calculations:

Results: Density of solid -

Density of liquid -

SCIENCE 103

Chemistry | Properties of Matter | Investigation 1

Problem: To discover some of the properties of solids, liquids and gases.

Materials: Regularly shaped pieces of iron, copper, aluminum, plastic and wood;
containers of water, anti-freeze, motor oil, water base paint, mercury;
cylinders of oxygen and helium;
100 ml beakers; 100 ml graduated cylinders;
metric ruler; thread.

Experimental Design: Prepare samples of oxygen and helium gas by filling two rubber balloons with these gases and tying them tightly with thread.

Place your materials in three piles on your laboratory table: solids, liquids and gases.

Determine the volume of each solid and record it on the data chart.

Determine the volume of each liquid and record it on the data chart.

Try to determine the volume of each gas.

Take each solid and try to change its shape. Use any equipment you need.

Do the same for each liquid and each gas.

Determine the mass (weight) of each solid with the balance and record it on the data chart. Do the same for each liquid and gas.

Data:

Material	Volume	Mass (Weight)
Iron		
Copper		
Wood		
Plastic		
Oil		
Water		
Paint		
Mercury		
Oxygen		
Helium		

Questions:

1. How did you measure the volume of the

   (a) Solids?

   (b) Liquids?

2. What difficulty did you encounter when you tried to measure the volume of the gases?

3. How did you change the shape of the

   (a) Solids?

   (b) Liquids?

   (c) Gases?

4. If you were to explain the differences between solids, liquids and gases to someone who was completely "clued out" what would you say?

SCIENCE 103

Chemistry | Malleability | Investigation 2

Problem: To discover the meaning of "malleability" and to compare the malleability of several metals.

Materials: Flat piece of 1/2" steel plate one foot square; pieces of equal size of lead, aluminum, copper, iron, solder, brass; metric rule, hammer, chalk

Experimental Design: With a piece of chalk outline a square 3 cm x 3 cm on the steel plate.

Attempt to change the shape of the pieces of metal to fit into the 3 cm x 3 cm square.

Questions:

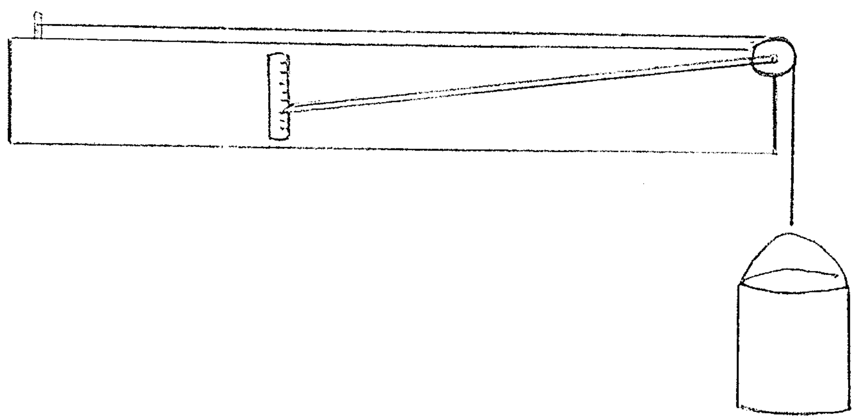
1. Which metal appears to be the hardest?
2. Which metal appears to be the softest?
3. Which one is the most malleable?
4. Why are some bearings made of brass or babbit metal?
5. Why are bits for drilling steel made of case hardened steel?

SCIENCE 103

Chemistry | Elasticity | Investigation 3

Problem: To discover the meaning of "elasticity" in solids and to compare the elasticity of several wires.

Materials: Elasticity machine (see sketch);
wires of the same thickness of iron, aluminum, copper, chrome steel, and brass;
pail, water, 1000 ml beaker



Experimental Design: Use copper wire to set up the elasticity machine as shown in the diagram.

Fill the pail 1/3 full with water and set the pointer at the zero mark on the scale.

Add 1000 ml of water to the pail, read the scale and record it on the data chart. Add 1000 ml of water two more times, reading and recording the value each time.

Repeat with the other wires.

Data:

Material	1000 ml water	2000 ml water	3000 ml water
Copper			
Iron			
Aluminum			
Chrome			
Brass			

Questions:

1. What do you think "elasticity" means?

2. Which wire was the most elastic?

3. Which wire was the least elastic?

4. Which wire would be the best for making barbed wire fences?

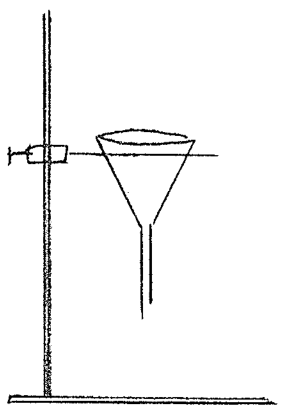
5. Which wire would be the best for snaring animals on a trap line?

SCIENCE 103

Chemistry — Viscosity — Investigation 4

Problem: To compare the viscosities of some oils.

Materials: 2 different grades of oil (#10 and #30)
small steel ball, funnel, beaker, 100 ml graduated cylinder



Experimental Design #1: Put a funnel on a stand as shown. Place your finger over the end and fill the funnel with oil No. 1. Remove your finger and count the time (in seconds) for the oil to flow out of the funnel.

Repeat with oil No. 2. Again record the time for the funnel to empty.

Heat the two oil samples to 90°C in a water bath. Put oil No. 1 into the funnel and time again. <u>NOTE</u>: Use a cork, not your finger, to stop the oil from flowing out while filling the funnel.

Repeat with oil No. 2. Record the time again.

Fill the funnel with soap solution and record the time for the funnel to empty.

Data:

Grade Sample	Time at Room Temp.	Time at 90°C
Oil #1		
Oil #2		
Soap		

Experimental Design #2: Place oil No. 1 into a graduated cylinder. Gently place the steel ball on the top surface of the oil and find the time it takes the ball to drop to the bottom.

Repeat with oil No. 2.

Repeat for soap solution.

Data:

Sample Grade	Time (seconds) for ball to drop
Oil #1	
Oil #2	
Soap	

Questions:

1. Which grade of oil is thicker - i.e. "more viscous", No. 10 or No. 30?

2. Which is more viscous, soap solution or oil?

3. An oil can is left outside in cold weather. How do you "thin" it to be able to pour it more easily?

4. A shock absorber is a piston immersed in oil.

   (a) How does this mechanism help to "absorb shocks"?

   (b) If a shock absorber is weak, what type of oil would you put in it?

SCIENCE 103

Chemistry | Viscosity | Investigation 4

Problem: To measure the viscosity of motor oils of various S.A.E. numbers.

Materials:
100 ml graduate cylinder
ball bearing
Thermometer
3 foot piece of glass tubing (sealed)
stop watch
2 foot wire with loop at one end

Experimental Design #1: Fill a 100 ml graduate with S.A.E. 10 oil. Record the temperature of this oil on the data table. Drop a ball bearing in the oil and reasure the time taken to reach the bottom.

Remove the bearing with the wire loop and measure the time again. Record these times on the data table.

Repeat at the same temperature with S.A.E. 20, 30 and multigrade S.A.E. 20-10W. Record all temperatures and times.

Heat the oils to about 40°C and repeat the above experiments. Record all times and temperatures on the data table.

Data:

S.A.E. #	Time at room temperature Trial 1	Trial 2	Average time
10			
20			
30			
20-10W			

S.A.E. #	Time at ______°C Trial 1	Trial 2	Average Time
10			
20			
30			
20-10W			

Experimental Design #2: Fill the sealed glass tube with a sample of S.A.E. 10 oil to within 2 cm of the top, after you have recorded its temperature. Place your finger over the open end of the tube and turn it upside down. Measure the time taken for the bubble of air to reach the top. Record this time on your data sheet.

Repeat with the other grades of oil at the same temperature. Record your data.

Heat the oils to about 40°C and repeat the experiment at this temperature. Record your times and temperatures.

Data:

S.A.E. #	Time at room temperature Trial 1	Trial 2	Average time
10			
20			
30			
20-10W			

S.A.E. #	Time at _____ °C Trial 1	Trial 2	Average Time
10			
20			
30			
20-10W			

Questions:

1. Which S.A.E. number oil has the greatest viscosity?
2. Which S.A.E. number oil has the least viscosity?
3. At which temperature is a particular oil the thinnest?
4. Why do we use S.A.E. 10 in the winter?
5. Why do we use S.A.E. 30 in the summer?

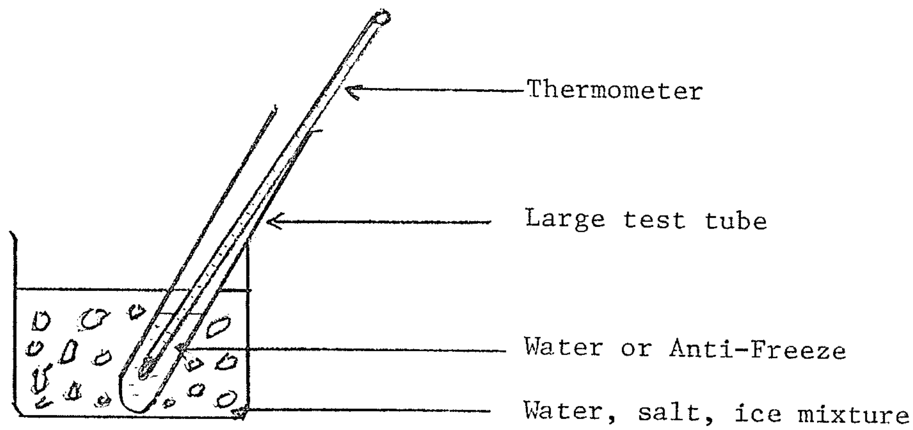
SCIENCE 103

Chemistry | Freezing Points | Investigation 5

Problem: To measure the freezing point of water and of anti-freeze.

Materials: 300 ml beaker, 2 large test tubes (30 x 150 mm), Centigrade thermometer reading to -10°, sodium chloride, ice, water, anti-freeze, graph paper.

Experimental Design: Set up the apparatus as shown in the diagram below:



Fill the beaker half full with cold water and dissolve at least 6 teaspoons of salt in it. Add chopped ice to the two-third level. Pour some water into the large test tube, place the thermometer in the water and place the test tube into the beaker of ice and water.

Read the temperature every 30 seconds until the water in the test tube is solidly frozen.

Record these temperatures on the data table.

Draw a graph with this data, placing time on the x axis and the temperature on the y axis.

Repeat this experiment using anti-freeze instead of the water.

Record the temperatures on the data table.

Draw a graph using this data as before.

Data:

Water:

Time (seconds)	Temperature ^{o}C

Anti-Freeze:

Time (seconds)	Temperature ^{o}C

Questions:

1. From the graph, what is the F.P. of water?
2. From the graph, what is the F.P. of anti-freeze?
3. Why do we use windshield anti-freeze in cold weather?
4. Who do the cooling systems of most Canadian cars require a change from water to anti-freeze in the winter?

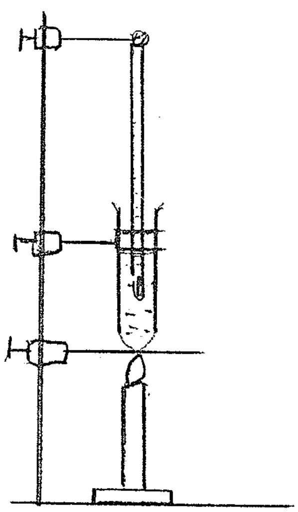
SCIENCE 103

Chemistry | Boiling Points | Investigation 6

Problem: To measure the boiling point of water.

Materials: 1 large test tube (30 x 150 mm), Centigrade thermometer, water, graph paper, burner

Experimental Design: Set up the apparatus as shown in the diagram below-



Fill the test tube about 2/3 full with water.

Begin to heat gently and read the thermometer every 30 seconds until the water has been boiling for three minutes.

Record these temperatures on the data chart.

Draw a graph of this data, placing time on the x-axis and the temperature on the y-axis.

Data:

Time (seconds)	Temperature °C

Questions:

1. From the graph, what is the B.P. of water?
2. Why does the temperature of the water not go any higher than the boiling point?

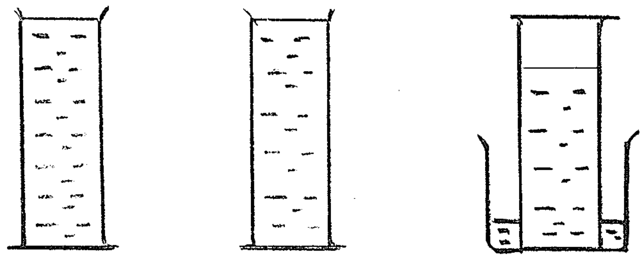
SCIENCE 103

Chemistry | Chemical Changes | Investigation 7

Problem: To demonstrate a chemical change in which a gas is produced. To show that chemical changes occur in a certain order.

Materials: 250 ml beaker, 100 ml graduated cylinder, dilute HCl, magnesium ribbon.

Experimental Design:



Fill the graduated cylinder right to the top with dilute HCl. Measure 2 cm of magnesium ribbon and place it in the acid. Immedi̇ately place a beaker on the cylinder as shown in the diagram and invert the whole apparatus.

Allow the apparatus to stand in this way until the gas has all collected at the top of the cylinder.

Measure the amount of gas collected. Record this amount and the measurement of the magnesium strip on the data table.

Repeat with two more different lengths of magnesium ribbon and record the data on the chart.

Data:

Length of Mg ribbon (cm)	Volume of gas collected (ml)

Draw a graph of the data collected. Place the length of ribbon on the x axis and the amount of gas produced on the y axis.

Questions:

1. How do you know that this was indeed a chemical change?

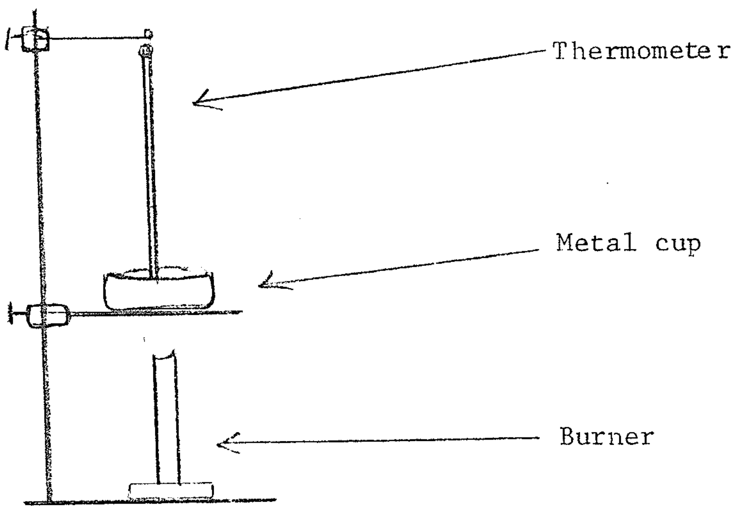
SCIENCE 103

Chemistry — Flash Point & Fire Point — Investigation 8

Problem: To measure the flash point and the fire point of several different SAE oils.

Materials: Ring stand, ring clamp, wire gauze, asbestos pad, flash point thermometer (reading to 450°C), metal cup, S.A.E. 10 oil, S.A.E. 20 oil, 2 burners.

Experimental Design: Set up the apparatus as shown in the diagram below.



Fill the cup exactly half with SAE 20 oil. Light the bunsen burner and adjust the flame so that the oil temperature does not rise faster than 2 degrees per minute.

Light the second burner and adjust the flame so that the flame is no larger than one quarter of an inch. Keep this flame at this small size. Pass this small flame over the surface of the oil in the cup every 15 seconds until a brief momentary bluish flame appears. This is the flash point. Record the temperature when this happens.

Continue to heat the oil and pass the small torch over its surface until the oil burns steadily. This is the fire point. Record the temperature when this happens.

Stop heating. Smother the burning oil with the asbestos pad.

Record the data on the data sheet.

Repeat the foregoing experiment with SAE 10 oil.

Record the flash and fire points.

Data:

Oil grade	Flash Point	Fire Point
SAE 10		
SAE 20		

Questions:

1. Why is the fire point higher than the flash point?
2. Does the temperature of an engine ever go high enough for the oil to flash or to burn?
3. Why should an auto mechanic want to know the flash point of the oil he is using?

SCIENCE 103

Chemistry | Mixtures & Compounds | Investigation 9

Problem: To study the physical properties of lead and tin, and to produce an alloy with them.

Materials: pieces of tin and lead foil of the same thickness and approximately 3" square.

Experimental Design: Examine the surface of each piece of metal. Scratch each piece with a nail and find which surface is harder. Clean the surface of each with emery paper and record the appearance and hardness of the newly exposed surface.

Heat each material separately in a crucible. Mix the materials together in a crucible. Add 3 gm of ammonium chloride and heat strongly with a burner for 5 minutes.

Pour the alloy onto an asbestos mat and compare its appearance and hardness with those of the original materials.

Record the appearance and hardness of newly exposed oxidized surfaces of tin and lead and the alloy formed.

Questions:

1. Which of the materials is the softest?

2. Which material has the lowest melting point? Look them up.

3. What is the value of the alloy produced?

4. What is meant by the term "fusible alloy"?

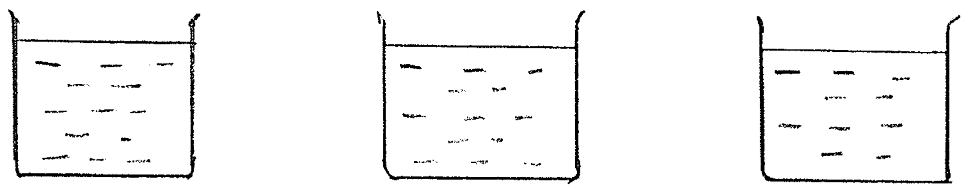
SCIENCE 103

Heat | Temperature I | Investigation 1

Problem: To determine if your fingers are a good thermometer.

Materials: 3 - 150 ml beakers
water

Experimental Design:



Arrange 3 150 ml beakers as shown in the diagram. Pour 100 ml of hot water into A, 100 ml of cold water into C, and 50 ml of hot and 50 ml of cold water into B.

Put one finger into A for about 30 seconds. At the same time, place another finger into C for about 30 seconds.

Now place both fingers into B.

Questions:

1. Does the temperature of the water in beaker B appear the same to both fingers?

2. Are your fingers a good thermometer? Explain.

3. Does your body measure temperature or does it measure a difference in temperature?

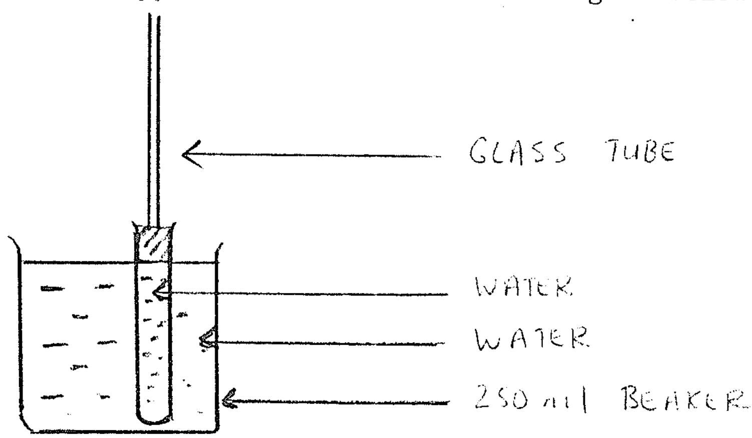
SCIENCE 103

Heat | Temperature II | Investigation 2

Problem: To construct a simple thermometer.

Materials: 250 ml beaker, 30 x 150 mm test tube, #4 one hole stopper, 5 mm glass tubing 45 cm long.

Experimental Design: Assemble the apparatus as shown in the diagram below:



When you insert the glass tubing into the rubber stopper, make sure that the tubing is flush with the bottom of the stopper. This prevents air from being trapped at the top of the test tube.

Pour some warm water into the beaker and mark the height of the water in the glass tube.

Pour some cold water into the beaker and mark the height of the water in the glass tube.

Questions:

1. Would this instrument serve as a reliable thermometer?

2. (a) Why couldn't you use this thermometer to measure the temperature of boiling oil?

   (b) Why couldn't you use this thermometer to measure the temperature of your deep freeze?

3. Could this simple thermometer you made be used to measure outdoor winter temperatures?

SCIENCE 103

Heat | Temperature III | Investigation 3

Problem: To calibrate a mercury or alcohol thermometer.

Materials: Laboratory thermometer, masking tape, 2 - 250 ml beakers, crushed ice, water, bunsen or alcohol burner.

Experimental Design: A standard thermometer is built like the simple thermometer you constructed in Investigation 2, except that it is filled with mercury or alcohol. Could you explain why a different liquid is used?

Place a strip of masking tape over the scale of the thermometer so that you cannot see the numbers but so that you can still see the mercury.

Place the thermometer into a beaker filled with a mixture of crushed ice and water and mark the position of the mercury as 0 degrees.

No place the thermometer into a beaker of boiling water and mark the position of the mercury as 100 degrees.

Divide the distance between these two marks into 10 equal spaces and mark these 10^o, 20^o, 30^o, 40^o, 50^o, 60^o, 70^o, 80^o and 90^o.

Now slowly remove the masking tape to see how well your markings coincide with the markings on the thermometer.

Questions:

1. In degrees, how well did your markings coincide with the thermometer markings?
2. Which liquid is used to determine the 0^o and the 100^o markings on a thermometer?
3. Explain how you might make a thermometer out of a milk carton and a straw.
4. Why would ammonia not be a good liquid to use in a thermometer?
5. Could liquid tungsten be carried in a lead container? Explain why or why not.
6. Why is water not used as a liquid in thermometers?

7. Why are alcohol thermometers used for measuring outdoor temperatures while mercury thermometers are used for measuring the temperature of boiling liquids?

Data: Table of Freezing Points and Boiling Points:

Substance	Freezing Point (°C)	Boiling Point (°C)
water	0	100
alcohol	-115	78.5
mercury	- 38.8	356
tungsten	3370	5900
iron	1773	4300
lead	327	1620
ammonia	- 77	- 33

SCIENCE 103

Heat | Heat I | Investigation 4

Heat Measuring Machine:

Students often confuse the term "heat" with the term "temperature". To understand the difference, try the following experiment:

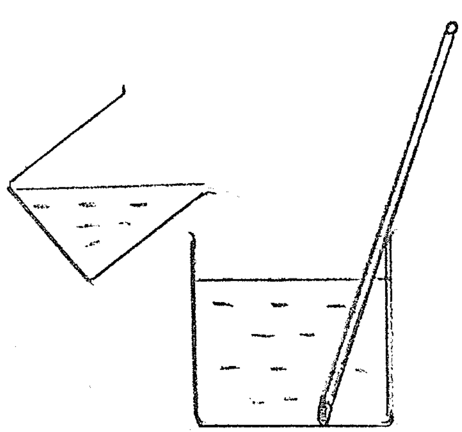
Put 50 ml of cold water into each of two beakers. Place an alcohol burner under each one for 3 minutes and measure the temperature increase in each one. Since the amount of heat given off by each burner in three minutes must have been the same, one would expect that the temperature increase would have been the same. Was it?

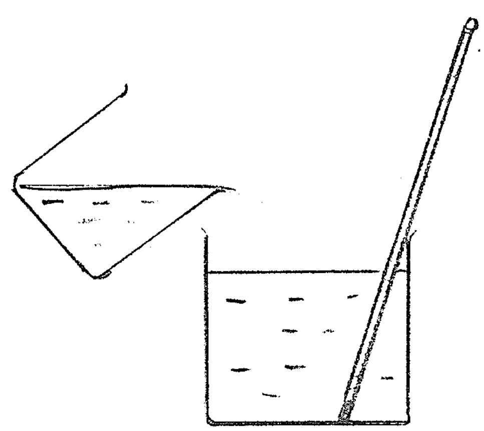
From this brief experiment it is obvious that heat involves more than just temperature. This investigation and the following ones will indicate the factors that determine the amount of heat gained or lost by a material.

In order to measure heat, we need an instrument. We will call this instrument a "Heat Measuring Machine". Suppose you had a bathtub with cold water in it. How many different ways would there be of heating it? Since a bathtub filled with water is too large for a classroom, we will use a beaker filled with cold water. The temperature by which this cold water increases in any one investigation will indicate how much heat has been put into the water. As such this beaker of cold water will be our "Heat Measuring Machine".

Problem: To determine if the heat given off by a material depends on its mass.

Materials: 2 heat measuring machines (2 250 ml beakers each with 100 ml of cold water), 2 thermometers, 250 ml beaker.





Experimental Design:

Pour 100 ml of cold tap water into each of two 250 ml beakers. Label each of these "Heat Measuring Machine". Place a thermometer into each one and record the temperature in degrees.

Pour 50 ml of hot water into one Heat Measuring Machine and 150 ml of hot water into the other.

Determine the temperature change in each machine and record on the data chart.

Data:

	Change in Temp.
50 ml Hot water	^oC
100 ml hot water	^oC

Questions:

1. Which sample of hot water, the 50 ml or the 100 ml, had the larger amount of heat?

2. How many times as much heat did the 100 ml of hot water have as compared with the 50 ml of hot water?

3. Name one factor that determines the amount of heat.

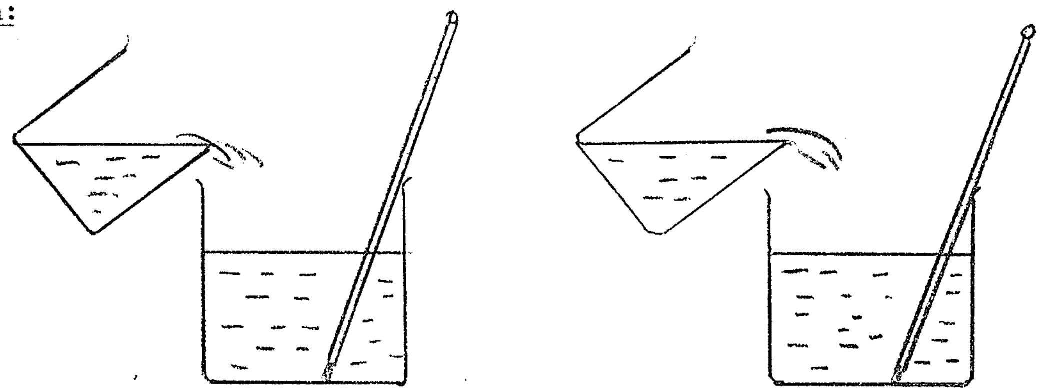
SCIENCE 103

Heat | Heat II | Investigation 5

Problem: To discover if the temperature of a material affects the amount of heat that may be given off by that material.

Materials: 2 heat measuring machines, 2 250 ml beakers, 2 thermometers.

Experimental Design:



Pour 50 ml of boiling water into a 250 ml beaker and 50 ml of warm (55°C) water into another 250 ml beaker.

Set up two heat measuring machines as described in Investigation 4.

Pour the boiling water into one heat measuring machine and the warm water into the other.

Determine the temperature change in each heat measuring machine, record these on the data chart.

Data:

	Temperature Change
Boiling water	°C
Warm water	°C

Questions:

1. Which beaker, warm or boiling, contained the larger amount of heat?

2. In Investigation 4 you discovered one factor that determines the amount of heat. Name a second factor that determines the amount of heat.

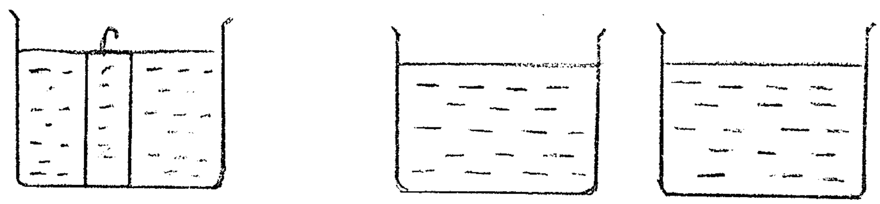
SCIENCE 103

Heat | Heat III | Investigation 6

Problem: To discover if the kind of material affects the amount of heat given off even though the temperature and mass are the same.

Materials: One 250 ml beaker, a piece of metal such as aluminum, 2 thermometers, 2 heat measuring machines.

Experimental Design:



Determine the mass of the piece of metal. Place the metal and an equal mass of water into a 250 ml beaker.

Heat the water to the boiling point and allow it to boil for several minutes.

While the water is boiling, set up two Heat Measuring Machines.

Place the piece of metal into one Heat Measuring Machine and the boiling water into the other.

Determine the temperature change in each Heat Measuring Machine and record these on the data chart.

Data

	Temperature Change
Aluminum	^{o}C
Hot water	^{o}C

Questions:

1. Which contained the larger amount of heat, the metal or the hot water?

2. In Investigation 4 and 5 you discovered two factors that determine the amount of heat. Name a third factor that determines the amount of heat.

3. Approximately how many times as much heat did the water have compared to the aluminum?

4. Which would heat a bathtub of cold water more, 2 lbs of aluminum at 100 ^{o}C or 2 lbs of water at 100^{o}C?

5. Why is a lake cooler during the day but warmer during the night, than the land around it?

6. Why does a water cooled engine take longer to heat up and longer to cool off than an air cooled engine?

7. Explain why a Morris Minor engine would cool off faster than a Cadillac engine?

8. What are the three factors that affect the amount of heat given off?

SCIENCE 103

Heat | Calories | Investigation 7

Problem: To compare the heat lost by cold water with the heat gained by hot water when hot water is added to cold water.

Materials: 2 250 ml beakers, 1 thermometer.

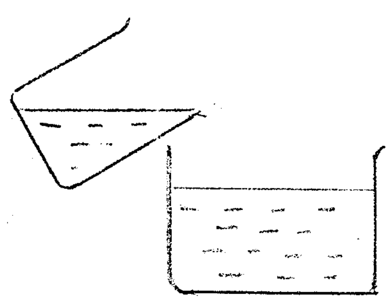
Experimental Design: In the last 3 investigations you found that three factors affected the amount of heat. In each case you measured the amount of heat by the 100 ml of water in the Heat Measuring Machine.

Since 100 ml of water are rather arbitrary, scientists usually use only 1 g of water. They define the amount of heat by a unit called a "calorie".

Whenever <u>one gram of water is heated by one degree Centigrade</u>, scientists say that <u>one calorie of heat has been added</u>. How many calories would be added if one gram of water were heated by 2 degrees Centigrade? How many calories would be added if 2 grams of water were heated by one degree Centigrade?

To find the number of calories, you simply multiply the number of grams of water times the number of degrees Centigrade of temperature change.

Heat (Calories) = Mass (g of water) x temp. change (^{o} C)



Pour 50 g of cold water into a 250 ml beaker. Determine the temperature of the water and record it on the data chart.

Pour 40 g of hot water into a second beaker. Determine the temperature and record it on the data chart.

Pour the cold water into the hot water. Determine the final temperature and record it on the data chart.

Data:

Temperature of hot water	^{o} C
Temperature of cold water	^{o} C
Final temperature	^{o} C

Questions:

1. (a) By how many degrees did the temperature of the cold water increase?
   How many calories of heat did the cold water gain? (That is, 50 grams x temperature increase).

   (b) By how many degrees did the temperature of the hot water decrease?
   How many calories of heat did the hot water lose? (That is, 40 grams x temperature decrease).

   (c) Compare answers (a) and (b). Was the heat lost equal to the heat gained?

2. How many calories are needed to heat 50 g of water from 20^{o} C to 70^{o} C?

3. How many calories are needed to raise the temperature of 800 g of water from 10^{o} C to the boiling point?

4. How many calories of heat does a cup with 90 g of coffee lose as it cools from 80^{o} C to room temperature (20^{o}C)?

5. How many calories of heat are needed to raise the temperature of 100 g of aluminum from 20^{o} C to 50^{o} C?

   (HINT: Aluminum holds only 1/5 as much heat as water.)

SCIENCE 103

Heat | Heat of Fusion | Investigation 8

Problem: To measure the heat of fusion (freezing) of water.

Materials: Ice, 250 ml beaker, 1 thermometer, balance, glass rod or stirring rod.

Experimental Design: You have probably noticed that a steam burn hurts more than a burn caused by boiling water. You may also have noticed that water takes a longer time to freeze than it takes to cool.

In the last investigation you learned how to measure heat quantitatively in calories.

In this investigation you will measure the amount of heat involved in the changing of water to ice.

Pour 100 g of water at room temperature (20°C) into a 250 ml beaker. This is your Heat Measuring Machine.

Place 20 g of ice into the water and stir until all the ice has melted. Determine the water temperature and record it on the data chart.

Data:

Water temperature before ice is added	° C
Water temperature after ice is melted	° C

Questions:

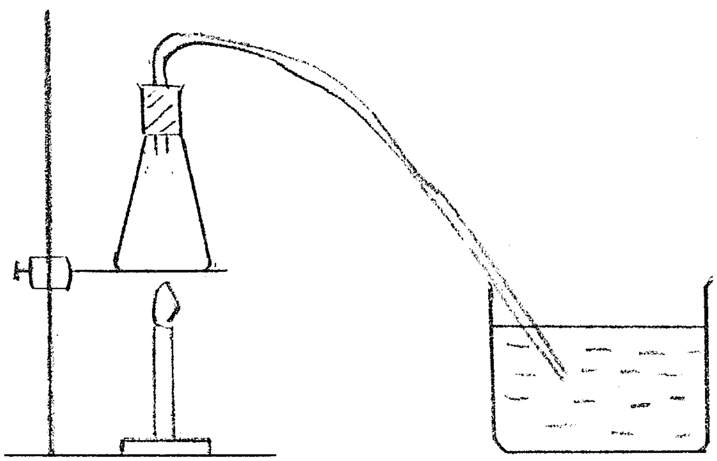
1. How many calories of heat did the water lose?
2. How many calories did the ice require to melt?
3. How many calories are required to melt one gram of ice?
4. How many calories would it take to freeze 200 g of water?
5. How many calories would it take to melt 200 g of ice?
6. Why is a lake still frozen in mid-May even though it may be warm outside?
7. Why does a pail of water in the basement keep vegetables from freezing?

SCIENCE 103

Heat | Heat of Vaporization | Investigation 9

Problem: To measure the heat of vaporization of water.

Materials: 1 steam generator, 1 250 ml beaker, balance, thermometer.



Experimental Design: Pour 100 g of water at room temperature (20°C) into a 250 ml beaker. This is your Heat Measuring Machine.

With a balance, determine the mass of your Heat Measuring Machine.

Leaving the Heat Measuring Machine on the balance set the scale for 5 g more than the mass of the machine.

Place the hose from the steam generator into the water in the Heat Measuring Machine and bubble steam into the water until the balance is again balanced. You have now added 5 g of steam to the water.

Determine the temperature of the water and record it on the data chart.

Data:

Water temperature before steam is added	°C
Water temperature after steam is added	°C

Questions:

1. Why does a steam burn hurt more than a burn caused by boiling water?

2. Why is it always cooler after a rain?

3. How does the human body cool itself when overheated?

4. A pot which it takes 5 minutes to bring to a boil may take an hour to boil dry. Explain.

5. Why can steam heating be used to heat every part of a large building evenly, while a hot water system leaves the remorte parts of the building cool?

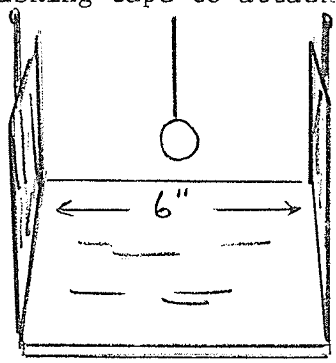
SCIENCE 103

Heat | Radiation | Investigation 10

Problem: To compare the rates at which a black surface and a white surface absorb heat by radiation.

Materials: Steel ball or bolt, bunsen burner, thermometers, masking tape, board with a black metal surface and a white metal surface attached to opposite sides.

Experimental Design: Attach 2 thermometers to the apparatus as shown below. Use masking tape to attach the thermometers.



Attach the steel ball to an iron wire and heat intensely for about 5 minutes.

Suspend the hot ball exactly half way between the two plates and read the temperature on the two thermometers every 30 seconds for 3 minutes.

Record the temperature readings on the data chart.

Data:

Time	Temperature at Black surface	Temperature at White surface

Question: Which surface color absorbs radiant heat the fastest?

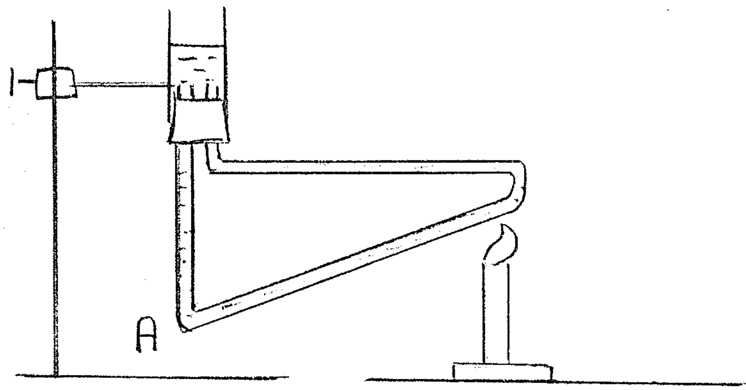
SCIENCE 103

Heat | Convection | Investigation 11

Problem: To show a convection current in a liquid.

Materials: Glass tubing, glass cylinder, 2 hole rubber stopper, thermometer, bunsen burner, water, ice cubes, wood chips.

Experimental Design: Arrange the equipment as shown in the diagram below.



Place ice oubes at point A. Place a thermometer into the water in the top cylinder. Place a burner in the position indicated and proceed to heat very gently.

Read the thermometer every 30 seconds for 3 minutes. Record the temperature readings on the data chart.

Watch the movement of the small bits of wood chips.

* Top container may be made in either one of two ways:
(a) large test tube with bottom removed.
(b) large diameter plastic or metal tube cut in short lengths by vocational students.

Data:

Time	Temperature

Questions:

1. Describe the movement of the wood chips.

2. Why did the bits of wood chips move as they did?

3. Why did the water temperature in the top cylinder change?

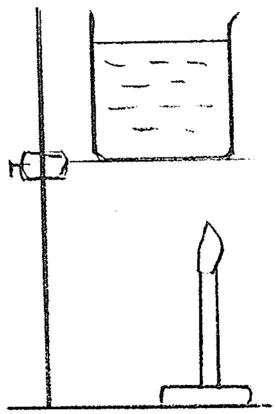
SCIENCE 103

Heat | Convection | Investigation 12

Problem: To show a convection current in water.

Materials: Ring stand, ring clamp, burner, wire gauze, 500 ml beaker, water, potassium permanganate.

Experimental Design: Set up the apparatus as shown in the diagram below:



Make sure that the burner is set away from the middle of the beaker.

Drop 3 crystals of potassium permanganate into the beaker just above the burner.

Light the burner and allow the water to heat for about five minutes. Carefully observe the coloring from the potassium permanganate crystals.

Questions:

1. Sketch a picture of what you saw happening to the color.

2. In what direction did the hotter water move?

3. In what direction did the colder water move?

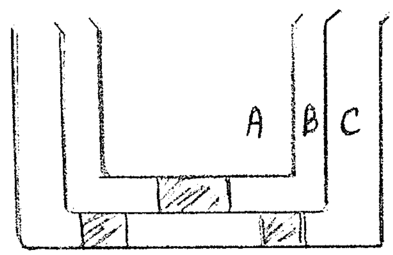
SCIENCE 103

Heat | Conduction | Investigation 13

Problem: To see how heat is conducted through some materials. To compare the rates at which heat is conducted through several different materials.

Materials: 3 glass or metal containers which fit into each other. 3 thermometers, water, sawdust or wood shavings, rockwool or fiberglass insulation.

Experimental Design: Place the three containers one inside the other as shown in the diagram below:



(a) Pour water at 100° C into space B and water at 20° C into spaces A and C.
Place a thermometer into each of the three containers and take a temperature reading every 30 seconds for five minutes. Record your readings on the data chart.

(b) (i) Empty the water from each container and dry with a paper towel. Fill space B with sawdust. Pour water at 100° C into space C and water at 20° C into space A. Place a thermometer into A and C and take a temperature reading every 30 seconds for 5 minutes. Record your temperature readings on the data chart.

(ii) Replace the wood sawdust with fiberglass insulation and repeat the experiment (i). Record your temperature readings on the data chart.

Data:

(a)

Time	Temp. in A	Temp. in B	Temp. in C

Data:

	Time	Temp. in A	Temp. in C
(b) (i)			
(b) (ii)			

Questions:

1. In which direction does heat conduct?
2. When is the rate of heat conduction the greatest?
3. Which material - wood shavings or fiberglass - is the better insulating material? Why?

SCIENCE 103

Heat | Radiation | Investigation 14

Problem: To show how heat is radiated from a hot surface and to compare the rates at which heat is radiated from a black surface and from a white surface.

Materials: 2 metal boxes - 10 cm x 10 cm x 10 cm, one painted black and one painted white, 2 thermometers, water.

Experimental Design: Pour hot water into both the white and the black containers. Hold a thermometer 10 cm in front of each container. Take both temperature readings every 30 seconds for 3 minutes. Record the temperature readings on the data chart.

Data:

Time	Temp. 10 cm from White surface	Temp. 10 cm from Black surface

Questions:

1. How does heat travel from the hot water to the thermometer?

2. What color surface radiates the greatest amount of heat?

SCIENCE 103

Heat | Conduction | Investigation 15

Problem: To see how heat is conducted through several different metals and to compare the rate at which the heat is conducted.

Materials: Rods about 12 inches in length of as many metals as possible - aluminum, copper, brass, iron, etc. paraffin candles, metric ruler, alcohol or bunsen burner, stand with perpendicular clamp, watch with second hand.

Experimental Design: Take each rod and drip a drop of wax from your burning candle at 2 cm intervals along the rod.

Attach one of the rods to a stand with a perpendicular clamp. Leave the perpendicular clamp attached to the stand in the same position for each rod.

Heat the end of the rod with your berner and measure the time taken for each drop of wax to melt. Record the time on the data sheet.

Repeat with each of the rods. Make sure that your burner flame is always the same height and that you heat only the end of each rod. Record the times taken to melt the wax on the data chart.

Data:

Rod used	Time taken for all wax to melt
Aluminum	
Copper	
Brass	
Iron	

Questions:

1. In which direction does heat travel when it conducts?
2. Which metal is the best conductor of heat?
3. Which is the worst conductor of heat?
4. Compare the aluminum with the iron rod.

APPENDIX C

A SCALE TO MEASURE ATTITUDE TOWARD ANY SCHOOL SUBJECT

Form A

Edited by H. H. Remmers

Date____________________

e (optional)________________________________ Sex (circle one) M F

____________________________ Grade____________________________

ctions: Following is a list of statements about school subjects. Put a plus sign efore each statement with which you agree about the subjects listed at the left of tatements. The person in charge will tell you the subject or subjects to write the head of the columns to the left of the statements. Your score will not affect grade in any course.

1. No matter what happens, this subject always comes first.
2. This subject has an irresistible attraction for me.
3. This subject is profitable to everybody who takes it.
4. Any student who takes this subject is bound to be benefited.
5. This subject is a good subject.
6. All lessons and all methods used in this subject are clear and definite.
7. I am willing to spend my time studying this subject
8. This subject is a good pastime.
9. I don't believe this subject will do anybody any harm.
10. I haven't any definite like or dislike for this subject.
11. This subject will benefit only the brighter students.
12. My parents never had this subject, so I see no merit in it.
13. I am not interested in this subject.
14. This subject reminds me of Shakespeare's play -- "Much Ado About Nothing."
15. I would not advise anyone to take this subject.
16. This subject is a waste of time.
17. I look forward to this subject with horror.

APPENDIX "D"

TEST SCIENCE 103 FEBRUARY 1975

DIRECTIONS: Each one of the following questions has a specific short answer. Please place the answer to each question in the proper space on the answer sheet.

1. In which state of matter does the element mercury usually occur?

2. The chemical material in the cooling coils of a refrigerator that is used for cooling is called Freon. When the Freon is used for cooling it changes from one state of matter into another state of matter. What state of matter does it change to?

3. Number 10 oil is thinner or less viscous than number 30 oil. Is this a physical property of oil or is it a chemical property?

4. Gasoline burns very easily; in fact, when it is a vapour it burns so rapidly that it explodes. Is this a chemical property or a physical property of gasoline?

5. Solder is a material that is used in many shops in this school. One of the most common uses is in making good water tight connections in water pipes made of copper. In this kind of use does the solder go through a chemical change or does it go through a physical change?

6. When an iron nail is placed in a solution of blue copper sulfate one of the things that happens is that the copper ions pick up two electrons and plate onto the iron nail. Is this a physical change or is it a chemical change?

7. What sign is the electrical charge on an electron?

8. The element Carbon has an atomic number of 6 and an atomic weight of 12. How many electrons does an atom of Carbon have?

9. The element Aluminum has an atomic number = 13 and an atomic weight = 27. How many protons does an atom of Aluminum have?

10. The element Oxygen has 8 electrons, 8 protons, and 8 neutrons. What is its atomic weight?

11. The element Chlorine has 17 electrons, 17 protons, and 19 neutrons. What is its atomic number?

12. Is a copper pipe made up of an element or is it made up of a compound?

13. The liquid used in car batteries has the chemical formula H_2SO_4 .

    What is the common name of this liquid?

14. A certain chemical has the formula $CaCl_2$. What is the chemical name of this material?

15. A rectangular block has **a length** of 10 cem., a width of 6 cm., and a thickness of 4 cm. What is the volume of this block?

16. The volume of a piece of copper is measured by immersing the piece of copper in a graduated cylinder with water in it. If the water level in the graduated cylinder changes from 10 ml. to 27 ml. what is the volume of the piece of copper?

17. A piece of steel has a mass of 260 grams and a volume of 13 cubic centimeters. What is the density of this piece of steel?

18. A blob of solder has a volume of 12 cubic centimeters and a density of 7 grams/ cubic centimeter. What is the mass of this blob of solder?

19. A block of Magnesium is placed into a graduated cylinder containing 20 milliliters of water. The water level in the cylinder rises to the 25 milliliter mark. If the Magnesium has a mass of 825 grams, what is its density?

20. Change the number 10,000,000,000 into scientific notation.

21. Change the number 0.00005 into scientific notation.

22. Change the number 2.1×10^4 into standard notation.

23. Multiply the numbers 5.8×10^2 and 3.0×10^4 and express the answer in scientific notation.

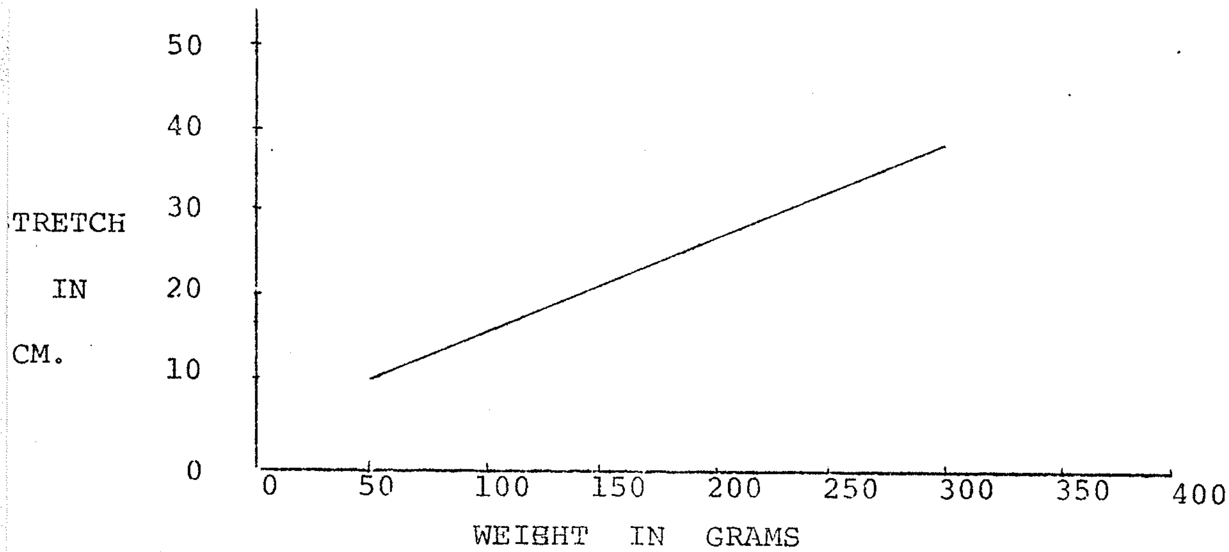
The next 3 questions refer to the following experiment:

A spring is attached to a stand and is slowly stretched by adding more and more weights to it.

The weights that are attached to the spring are measured in grams and the resulting stretch of the spring is measured in centimeters.

A graph of the weight attached to the spring agajnst the total stretch of the spring is drawn. Weight in grams is placed on the x axis and stretch in centimeters is placed on the y axis.

The graph is shown below:



24. If a weight of 125 grams was attached to the spring to what length in centimeters would the spring stretch?

25. If a 400 gram weight was attached to the spring to what length would the spring probably stretch?

26. If the spring were to stretch to a length of 25 centimeters, what would be the weight in grams of the attached weight?

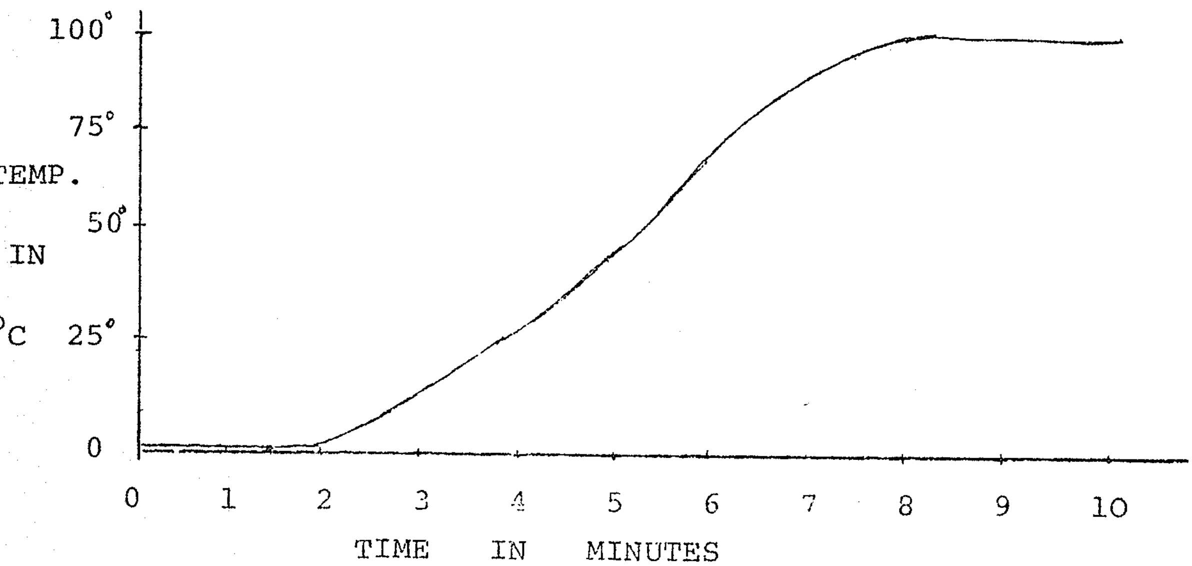
The next three questions refer to another experiment:

Some water with ice in it is placed in a beaker and is slowly heated till the water boils.

The time of the experiment is measured in minutes and the temperature is measured with a thermometer in degrees Centigrade.

A graph of the time in minutes against the temperature in degrees Centigrade is drawn. Time is placed on the x axis and temperature is placed on the y axis.

This graph is shown below:



27. From the graph, what is the temperature at which ice melts?

28. From the graph, what is the temperature at which the water boils?

29. From the graph, how long does it take from the time the last ice has melted till the time the water begins to boil?

30. The air temperature on a certain day is 32° Fahrenheit. What is this temperature in degrees Centigrade?

31. On a Centigrade thermometer, what is the temperature exactly half way between the temperature of melting ice and the temperature of boiling water?

32. A liquid can go through two different phase changes depending on whether it loses heat or gains heat. When a liquid loses heat which phase change can it go through?

33. A block of steel has a mass of 500 grams and a specific heat of 0.20. If its temperature goes up by 10 degrees Centigrade, how many calories of heat has it absorbed?

34. 100 milliliters of water at 60°C are mixed with 100 milliliters of water at 20°C. If no heat is lost to the air, what is the final temperature of the mixture?

35. Heat energy can be transferred in three ways: Convection, conduction, and radiation. By which one of these three ways is heat transferred into a room heated by a forced air furnace?

36. Most materials become larger in volume when they are heated. What is the scientific word that describes this increase in volume?

BIBLIOGRAPHY

Ausubel, David. "The Nature of Educational Research", _Educational Theory_, 3, 1953.

Bruner, J.S. _The Process of Education_. Cambridge, Mass: Harvard University Press, 1960.

Compton, B. Area Principal's Institute, Minnesota: University of Minnesota, 1963.

Cronbach, Lee J. "Course Improvement Thre Evaluation", _Teachers' College Record_, LXIV, May, 1963.

Education Service Center Region 1. _CVAE (Coordinated Vocational-Academic Curriculum Project, Evaluation Report_, Education Service Center Region 1, Edinburg, Texas, 1972.

Eisner, Elliot W. "The Evaluation and Research of Curriculum Materials", A paper presented at the annual meeting of the _American Educational Research Association_, Minneapolis, Minnesota, 1970.

Florida State University. The Callaway Gardens Conference on Building a Multiyear, Multidisciplinary, High School Science Program, Final Report. Tallahassee, Florida: Florida State University, 1971.

Gagne', R.M. (Ed.) _Psychological Principles in System Development_. New York: Holt, Rinehart, and Winston, 1962.

Gronlund, Norman E. _Stating Behavioural Objectives for Classroom Instruction_. London: Collier Macmillan Ltd, 1970.

Handbook of Research in Teaching. Chicago: Rand McNally, 1963.

Havighurst, R.J. and Stiles, L.J. "National Policy for Alienated Youth", _Phi Delta Kappan_, 1961.

Hedley, R.L. and Wood, C.C. Man U Teach. Winnipeg, Manitoba: University of Manitoba Press, 1974.

Herron, J.D. "Evaluation and the New Curricula", Journal of Research in Science Teaching, no. 4, 1966.

Hurd, P.D. New Directions in Teaching Secondary School Science. Chicago: Rand McNally, 1969.

Karlin, R. "Reading Skills for Slow Learners in Junior and Senior High School", The Clearing House, January, 1961.

Lindvall, C.M. and Cox, R.C. "Evaluation as a Tool in Curriculum Development: The IPI Evaluation Program", AERA Monograph on Curriculum Evaluation, No. 5. Chicago: Rand McNally, 1970.

National Committee on Employment of Youth. A Guide to the Development of Vocational Education Programs and Services for the Disadvantaged. New York: National Committee on Employment of Youth, 1969.

New York State Education Department. Guided Occupational Training: A Vocational Work Experience for Intellectually Limited and Educationally Handicapped Students, Final Report. Albany, New York: Bureau of Educational Research, New York State Education Department, 1969.

Nickel, K.N. "Better Education for Non-Academic Pupils", North Central Association Quarterly, April, 1957.

Potter, M.A. "The Slow Can Learn", Arithmetic Teacher, May, 1960.

Rayner, G.T. An Empirical Study of a Methodology for the Revision of Systematically Designed Educational Materials. Tallahassee, Florida: Florida State University, 1972.

Ritz, W.C. "Evaluation of Curriculum Installation: An Evaluation of a Two Year Installation of "Science - A Process Approach". Syracuse, New York: Eastern Regional Institute for Education, 1970.

Schaefer, C.J. et al (Eds.) Vocational- Technical Education: A Prospectus for Change. Boston: College of Education, Northeastern University, 1967.

Sizer, T.R. "Classroom Revolution: Reform Movement or Panacea?" Saturday Review, June 19, 1965.

Stake, R.E. "The Countenance of Educational Evaluation". Urbana: University of Illinois Center for Instructional Research and Curriculum Evaluation, 1966. (Mimeograph)

Stufflebeam, D.L. "The Use of Experimental Design in Educational Evaluation", A paper presented at the annual meeting of the American Educational Research Association, Minneapolis, Minnesota, 1970.

Tyler, R.W. et al (Eds.) Perspectives of Curriculum Evaluation. Chicago: Rand McNally, 1967.

Utley, Ishmael. "The Slow Learner in the Secondary School", Education, February, 1961.

Walbesser, H.H. "Curriculum Evaluation by Means of Behavioural Objectives", Journal of Research in Science Teaching, 1, 1963.

Watson, Fletcher. "Teaching Science to the Average Pupil", The Science Teacher, 34, 1967.

Welch, W.W. "Curriculum Evaluation", Review of Educational Research, 39, 1969.

Welch, W.W. "Evaluation of the PSNS Course", Journal of Research in Science Teaching, 2, 1972.