IMPACT OF INDEPENDENT INSTRUCTION

ON

THE ACHIEVEMENT SCORES OF SLOW LEARNER STUDENTS

by

GERALD ALBERT PURDY

B.A. (English), York University, 1971
B. Ed., University of Toronto, 1963

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ABSTRACT

This study compared the effectiveness of independent lesson reviews with teacher-directed lesson reviews using the same content material. Student improvement was measured by improvement of the mean scores of the students, as determined by their performance on teacher-made tests. The students taking part in the study were grade nine vocational students at W.J. Fenton Secondary School in The Peel Board of Education. The students were tested on their ability to recall names of equipment, on their comprehension of a scientific phenomenon and on their ability to apply a mathematical formula to quantify experimental results.

The predicted superior performance of the independent study technique was not confirmed. The students in the teacher-directed reviews performed equally well or better than the students using independent study techniques. However, during the study there was overall improvement in the scores of both groups of students indicating that the teaching strategies applied for this study were effective in assisting the students to improve their subject mastery.
Based on these findings it was concluded that independent study strategies are not superior to teacher-directed review methods for students who have learning disabilities but they do have some value in instructional situations where independent study methods must be used.
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CHAPTER 1: INTRODUCTION

1.1 Models Employing Independent Instructional Strategies

There is a long tradition in educational research which holds that a self-instructional program designed to meet the specific needs of a student, who is experiencing difficulty mastering his/her educational material, will assist the student in subject mastery. Block's Mastery learning theories, A.V. Canon's (1984) self-coaching strategies and Torgensen's (1977) application of student self-instruction on task performance are examples of current use of this technique.

Many educational program delivery models have been developed outlining the application of the self-instructional materials, employing technical aids to present information and applying systematic methods to organize and deliver the subject material students are expected to master. Many applications of computer-assisted instruction rely on students using independent instruction materials to master programs.

The Winnetka Plan of Carleton Washburn (1922) and Professor Henry Morrison's (1926) approach at the University of Chicago Laboratory School were early efforts to individualize programs and apply strategies of independent instruction. Although there was initial improvement in student performance in the experiments, these efforts were not followed through, mainly because of the lack of instructional
technology required to sustain a long term successful teaching strategy within a classroom setting.

John B. Carroll's "Model of School Learning" (1963) measured the time a student required to learn a task to a given criterion-reference level under ideal instructional conditions. His model stated that certain conflicting characteristics between the individual and the quality of his school instruction could be compensated for by the extra time the student required to master the tasks. The "ideal instruction" in Carroll's model was defined as quality of instruction, whereby each individual student was provided with a form of pedagogy by which he could understand the specific instructions and expectations required to master the school program. The teacher's role was the clarification of instruction. By applying a variety of instructional strategies from which the student could choose, the student was made aware of the exact expectations necessary for his/her mastery of the required subject material. According to Carroll's model each student would require a different amount of time to complete his/her assignments and meet the criterion reference for the course. Carroll contended that the majority of students, given clear instruction and varying amounts of time to master the material, will meet the educational objectives of the school program.

Bloom's model developed self-paced student instructional strategies. He advocated for a review process where the
subject materials were presented in a unique form using teacher aids for those students who failed to comprehend essential lesson objectives within the classroom setting. Bloom (1968) provided a method to apply Carroll's model as an effective classroom teaching methodology. He outlined procedures in which the individualized instruction could be managed within the context of ordinary group-based instruction and application of techniques and aids to assist students to comprehend the material. Following Bloom's procedures would make instruction more efficient, improve student interest and attitude and allow up to ninety percent of the class to obtain subject mastery of their school curricula.

The Direct Instructional System in the Teaching of Arithmetic and Reading (DISTAR) was another approach for obtaining improved student performance through specific emphasis on the instructional variables. Bateman's approach (1976) to teaching reading skills combined task-analytic programming, reinforcement principles and an emphasis on the attentional deficits of the student. The DISTAR approach follows his principles by using tightly structured instructional components and carefully sequenced teaching steps. Repetition, small segmented groupings of information, sequenced from easiest to more complex and using constant feedback and praise as rewards, are the main elements of this instructional methodology.

Bateman's material was aimed at students who had general
learning disabilities with I.Q. scores below 85 based on psycho-educational assessments. This marked a difference in application from Bloom's model. Bloom's model was designed for students who were having difficulty mastering their school program, yet their psycho-educational assessments placed them within the normal intelligence range and they were not assessed as having learning disabilities. Bateman's model recognized the political reality that educational instructions must improve the subject mastery of students designated as slow learners and reflected the changing policies within the educational scene.

Adelman's Interactional Model (1971) identified classroom environmental factors which negatively affect the ability of students to master subject material. He identified a number of factors within the classroom setting which contributed to poor school performance of students classified as slow learners.

Adelman's proposed methodology of instruction (1973), which he calls "Personalized Instruction", organized student programs into instructional objectives, applied small units in a sequential order from easy to more difficult and utilized formative testing and lesson sequencing similar to that proposed by Bloom. Adelman also outlined in detail the role of the teachers, educational administrators and the instructional resource requirements for a successful independent study program.
Each of the areas covered in this brief background description will be dealt with in detail in the literature review section, Chapter II.

1.2 Importance of Researching Independent Study Strategies

For this study an independent instructional program was designed to assist students with the specific variables which influence each student's ability to master his/her own educational program for the experimental group review. In order to assist the student's mastery of the basic skills and concepts related directly to the lessons on heat transfer, the classroom lessons used traditional instruction; the students performed experiments and the teacher lesson was composed of a group demonstration and group instruction designed to explain and consolidate the lesson material. During instruction the students took formative evaluations after completing the experiments and receiving lessons on how to quantify the results. The teacher used the data from the testing to set up an independent review program for the experimental group and to design a traditional review lesson for the control group. The students in the experimental group were directed to concentrate their review time on specific areas of weakness using the specific instructional aids and instructional strategies, which allowed for an independent study program. Thus, the review lessons for the experimental group were individual review programs tailored to overcome specific
deficits of the students. The students completed their independent review in the room designed to facilitate these specific review strategies.

Studies by Bloom (1968) and Bloom and Block (1973) indicated major improvements in the achievement level of slow learner students. The instructional material was presented in a sequential format best suited to the student's personal learning style and taught at a pace that allowed the student the time required for him/her to master the material. Of equal importance, their research indicated that instructional approaches can be applied within the classroom setting with a minimum of additional teaching resources. The practice of removing students for specialized instruction into a classroom setting categorized by their disabilities has serious side effects, which limit the effectiveness of the program and reduce student motivation. An individual instructional approach uses a variety of teaching aids such as computer-assisted instruction, slide and filmstrip presentations and allows the student to remain within the timetable classroom setting. The side effects, which occur as a result of extensive withdrawal from regular instruction, are, therefore, kept to a minimum. The proposed model, using individually designed reviews, provides a guideline which allows school administrators, program planners and teachers to adjust the learning environment and program. In her article comparing different instructional approaches, Wong (1979)
believes there are gains to be made in a student's subject mastery by applying individual instructional strategies to the student's programs.

Adelman's articles on the Resource Room Concept (1972) and Adelman and Taylor's research on motivation and behaviour problems (1980) lend support for pursuing a teaching strategy that employs individual instruction.

Historical Context: A common approach for delivering special programs to assist students who are slow learners employs streaming or segregated classes. Students of secondary school age who have demonstrated poor academic performance are often placed in a vocational school with a shop-based program. Teaching practical skill subjects in order to help students obtain future employment is viewed as a motivator for the students and as a program that will lead to early employment. Within the vocational setting they are further streamed into academic classes according to their test scores in English, writing and mathematics. Classes for students with behaviour problems or with other basic educational and special remedial needs are designed to deliver a very individualized program aimed at remediating or compensating for the deficits and/or disabilities of the student. Special materials, adjusted programs and small classes are designed to provide the special assistance that the student requires. Specialist teachers are provided by the school board to assist students with specific
learning disabilities, and to develop plans for students with emotional/behavioral problems. The effectiveness of this model is limited due to problems such as difficulty in making accurate classifications, handling parent and student resentment at being placed in special settings and coming up with viable programs for such a diverse group.

Three questions confront the use of a teaching model within a vocational school setting:

First:
Can the model assist in the identification of the specific difficulties the student is experiencing while in the classroom setting?

Second:
Can teachers provide effective individualized instruction within an integrated group setting?

Third:
Can the application of a programmed instructional approach have significant influence on the mastery of subject material by students in the normal classroom setting?

If the results of this study demonstrate that a specialized instructional approach within the vocational school setting can attain improved student achievement, it will be of value to the teachers and school program planners.

Psychological Context: Almost all the students taking part in this study have had extensive withdrawal programs and often were placed in segregated classes. (Appendix I details special withdrawal for students).

These students have been "labelled" as having learning
difficulties. Adelman (1971), Adelman & Taylor (1986) and Bloom (1976) argue that students "labelled" often live up to the lower performance expectations. The label becomes a self-fulfilling prophecy. The students are given many psycho-educational tests and specific skills tests while in withdrawal programs, which assess greater ability than their work shows. Shinn et al. (1986) and Wilson (1986) document cases where students constantly demonstrate lower achievement than their true potential and argue they are fulfilling the evaluator's expectations of lower achievement.

The design of this study integrates testing and reviews within the classroom setting. Bray (1985) and Reynolds (1979) argue that testing with direct feedback specific to the previous lessons and for specifically designed tasks met with favourable student response and provided more accurate assessment of the true comprehension of the students. The students taking part in this study all remain within the framework of a timetabled classroom and require no additional withdrawal or specialized remediation.

Societal Context: The need for studies of this nature is supported by an emphasis on identification and providing equal opportunities in education for all children and youth.

Bill 82 in Ontario is an example of legislation passed to guarantee that students are provided with instruction which will allow them to reach their maximum potential. Provincial
legislation and pressure from private advocacy organizations has resulted in efforts in schools to improve and expand services to students with special needs. Advocacy groups have sponsored various legislative actions to ensure special instructional assistance for students who have difficulty with basic academic skills. Within The Peel Board of Education this has resulted in hiring a variety of special education instructors, at the secondary school level, to assist students so identified. About fifty percent of the specialized instructors at secondary school level in The Peel Board of Education have been assigned to the six vocational schools. In the past four years, this has resulted in hiring specialized personnel over and above the classroom instructional requirements. At W.J. Fenton, the setting for this study, the following specialized assistance is available:

(a) a full time remedial specialist for working with students designated general learning disabilities (GLD) to assist them with their reading and basic mathematics skills;

(b) a full time specialist for students designated specific learning disabilities (SLD) to assist these students with strategies and compensation skills, particularly for those students designated as having communications exceptionalities;

(c) a half time behavioural specialist with clinical expertise and qualified to do psycho-educational
testing. This teacher has a full time aide to assist in working with students designated as having behaviour problems;

(d) a half time social worker, specifically hired to deal with multi-cultural and family problems, which can affect the student's school progress.

This additional staff complements three full time school counsellors and three full time work educational and co-operative education instructors. Out of a staff of sixty teachers and a student population of seven hundred students, nine instructors and a behavioural aide are designated as full time support service to assist students within the vocational school.

In many settings there is an increased emphasis on identification and diagnosis. As an example, The Peel Board of Education in Ontario currently has identified thirty five hundred students in vocational schools as having some form of learning exceptionality. This constitutes between 8% and 10% of the total secondary school population. This study is aimed at examining an instructional strategy that will help students with learning disabilities reach their maximum potential and enable them to remain in or return to regular classrooms.

Experiential Context: From the experiential viewpoint of the researcher this study serves three purposes. First, all vocational students spend over 40% of their time in
shop-related courses. Many of these courses have industrial instructional material which use programmed instruction with filmstrips, slides and tape backup. Independent instructional materials are produced for the auto service industry and the food service and hospitality industries. These are major areas of program studies and concentration for vocational students. These programs provide extensive instructional resource material to augment classroom teaching of basic vocational skills and for upgrading existing student skills to accommodate technological changes and new industrial practices. Many of the vocational students will be expected to upgrade their skills on their own when they are employed. Independent study skills learned at school will be valuable to students throughout their careers if their skills are retained after they leave school.

Second, independent study may assist in a more accurate and practical means of identifying instructional strategies and programs for basic level students. If the students can master subject material at their own pace, they may be more motivated to apply themselves to their subjects of interest and increase personal confidence in their ability to learn on their own.

Third, there is a need to develop visual/media literacy for students. Doerken (1984) suggests helping students develop the skill to manipulate more effectively the new learning environment encompassing computers and television which will
be essential for them to acquire the upgrading of their skills and knowledge as an ongoing process. The design of the review lessons allows the students participating in this study to interact with audio-visual and computer-generated programs in a structured learning environment which may help to develop visual/media literacy by these students.

1.3 Importance of an Individual Instruction Model

Student performance was compared from four perspectives. First, the ability of the student to recall accurately the specific names of test equipment used in a grade nine science experiment was measured. Memory and recall are important skills in most areas of learning. Verbal encoding is a very economical vehicle for storage of data in a student's memory bank and recall allows for rapid retrieval of information. Pavio's (1975) research shows that:

".... the verbal system has the advantage over imagery in retrieving the sequential order of items in memory. This implies that the verbal processes may be especially suited for logical thinking, which presumably requires an orderly progression of ideas towards some goal" (p.159).

Clearly, teaching students to develop their skills in memory and recall will have long term benefits for learning.

Second, the ability of the student to understand a natural phenomenon, in this case the transfer of heat, was evaluated. The depth of the student's understanding of this phenomenon is related to his/her comprehension ability. The
ability of the student to propose new extensions to existing experiments was also evaluated. It is important that these students develop the ability to mentally visualize a phenomenon that cannot be observed from basic sensory observations. As previously stated in this thesis, a key to comprehension of a phenomenon is the development of the student's ability to conceive a visual image, which explains the behaviour of unique experimental occurrences. This visual image must be used by the student to form a useful series of concepts related to the phenomenon. These concepts can assist the student in applying applications of the phenomenon to other experiments and to useful life experiences. The development of concepts as visual images allows for a broad, less specific, comprehension of the phenomenon. The information processing of visual concepts is organized in a special sense, whereas verbally encoded concepts, such as names of parts, are organized in a sequential sense.

"Visual imagery is specialized for parallel processing in the spatial sense, i.e. images are organized spatially, not temporally or sequentially, and the system is accordingly inefficient for sorting the sequential order of pictorial units" (Pavio, 1975, p.148).

It is important that these generalized concepts be guided towards a sequential and hierarchical form of understanding. The programs developed for this study were, therefore, developed and presented in a planned sequential manner with generalized concepts stressed first and then proceeding to
increasingly specific, more factual information.

Third, the student's ability to apply a mathematical formula to quantify a phenomenon in symbolized form and to make useful predictions of the behaviour of a phenomenon was evaluated. The ability to make predictions about behaviour of a phenomenon without constant testing is one of the most critical learning strategies. This provides a means for learning disabled students to apply concepts to a useful purpose and to accumulate knowledge and information with economy of time and effort. Nancy Dixon's (1983) article comparing symbol manipulation versus feedback response for learning disabled students highlights the importance for the student to develop the ability to manipulate symbols and to apply symbols to his/her particular environment.

"The word symbol, as used in this context, means written and spoken words and mathematical notation used to represent objects or ideas that are unrelated to the form of the notation ... The use of symbols results in the capacity to store and transfer information, internally manipulate ideas, hypothesize and plan, and anticipate the future" (p.61).

This study was undertaken for two reasons. If improved student scores and improved student motivation are obtained by using independent instructional strategies, this research will have direct application within the classroom situation for slow learning students, as the techniques can be relatively easy to apply within the instructional and economic resources of the school. Secondly, the author wishes to investigate if
individual lesson instruction, using proper rules of pedagogy, and based on a planned sequential model can improve the subject mastery and commitment to learning of special education students.

1.4 Description of Terms

The following terms referred to in this proposal have a definition generally accepted by vocational schools in Southern Ontario. Because these terms are in common use within the school system accepted definitions may be less specific than those in the literature or within other geographic areas. Appendix II outlines in detail the learning exceptionalities of the students who participated in the study.

An Independent Review Program: For this study an independent review program refers to the review strategies administered to one half of the sample. The individual program is composed of the following components:

(a) a video presentation of the experiment;
(b) a slide presentation with an audio cassette support explaining the names and functions of the parts of science equipment;
(c) a film strip presentation, with audio support, reviewing the laboratory set-up and experimental procedures, which students can apply;
(d) a computer drill and practice review with graphic presentations allowing the students to do review
Questions related directly to the specific experiments they have performed.

Sequential Instruction: The review lessons for the students taking the independent review were structured where the content was organized in sequential steps similar to the order of the lessons. The content of the independent review lessons was identical to that of the teacher-directed review lessons. Listed below are the components of this review program:

(a) Video presentation of experiment.
(b) A slide presentation with audio support explaining the names and function of the science equipment used in the experiment.
(c) A filmstrip presentation with audio support outlining procedures to do the experiment and procedures used to calculate the mathematical results.
(d) A computer drill and practice program simulating experiments.

Students in both groups spent the same amount of time on the review. Those students in the individual review would differ in the amount of time they spent on each of the four components outlined above, depending upon the results of their previous test scores.

Teacher-Directed Review: For this study a
teacher-directed review program refers to the review administered to the control group of students taking part in the experiment. This review program is teacher centred and is composed of the following components:

(a) The teacher reviews the previously completed experiment highlighting names and functions of the equipment. The teacher demonstrates the actual equipment used for the experiment as models for easy student recognition.

(b) The teacher explains the process for conducting the experiment and explains the central phenomenon to be observed. The teacher highlights the phenomenon using practical examples from everyday life.

(c) The teacher uses the chalkboard as the main instructional aid, particularly when developing the mathematical calculations required to quantify the experimental results.

(d) The teacher conducts a question and answer drill with the students to clarify the main points of the experiment.

(e) The students do example rehearsal questions, similar to those on the test papers. These are taken up by the teacher in the classroom to further solidify the students subject mastery.

The total time for the teacher-directed review was forty minutes. The students in the control group were taking their review at the same time as the students in the experimental
group were in the computer room taking their independent review.

General Learning Disabilities (GLD): Students classified as GLD have deficits in the underlying processes of auditory, visual, perceptual and motor control, which hinder performance in their school programs. The students designated GLD in this study were given psycho-educational evaluations to identify their disabilities. Their history of school performance related to their abilities in performing with their peer group on grade related material was also a criterion for GLD placement.

Slow Learner - (SL): The slow learner student does not have discernible process deficits but has demonstrated poor ability to master school related information at a rate similar to his/her peer group.

Specific Learning Disability - (SLD): This label applies to students whose progress in school is affected by a specific exceptionality, which impedes the student's academic progress. Communication and behavioral deficits are examples of SLD categories for these students.

Withdrawal programs (W): Many students within the test sample have a long history of being withdrawn from regular
classrooms and receiving assistance in a different setting in the elementary school. The most common subjects in which assistance has been provided are reading, writing, reading comprehension and basic mathematics.

**Learning Exceptionalities: Psycho-educational evaluations and school performance are the basis for classifying students as having a learning exceptionality.** Under Bill 82 The Board is required to provide an appropriate educational program designed to meet the specific needs of students who have learning exceptionalities. Students classified in Peel have the option of being placed in special educational programs in regular schools or placed in special schools designed to meet their needs. In The Peel Board of Education many of these programs are provided in schools designated as vocational schools. This study deals with students identified as having learning exceptionalities and who have accepted vocational school placement. Forty percent of the programs provided in vocational schools are shop-based. The instruction is at the basic level for academic programs along with considerable remedial assistance, strategy planning and work education built into the student's program.

**In-School Placement and Review Committee (IPRC):** Each vocational school holds regular IPRC meetings to evaluate progress and correct placement of students. These committees
have teachers, school psychologists and school administration discuss student progress and recommend changing a program within the school or offering placement in another school that best suits the student's needs.

1.5 Definitions Specific to the Science Experiments

The definitions listed below have a special context related to the experiments conducted by the students during this study.

The Phenomenon: For this study the "phenomenon" refers to the behaviour of heat when subjected to experiments conducted in a science laboratory. The "phenomenon" cannot be directly observed visually but requires an understanding at a conceptual level. In this study the student's understanding of the "phenomenon" is evaluated as a measure of his comprehension and his depth of understanding.

Conductivity: Conductivity is defined as a scientific fact of heat transfer. For this study a "conductivity" experiment is used to measure the student's ability to understand the comparative rate of heat transfer of metals, liquids and gases. The students are tested on their ability to apply a mathematical formula to quantify the rate of heat transfer and the mathematical results to make predictions related to the effect of heat transfer.
Mathematical application of a formula to quantify experimental data is defined as symbolization. In this study the student will apply the symbols of a mathematical formula to quantify experimental results and to make predictions about future applications of experiments. The symbolization applies an arithmetic formula familiar to the students.

1.6 Statement of the Problem:

The specific problem studied for this thesis determined the effect of an individual review treatment on the achievement scores of the sample. In order to evaluate improvement of achievement scores by students subjected to the independent instruction reviews the students were administered pre-tests and post-tests developed by the teachers. Measurement of the effectiveness of the treatment was specifically related to the student's overall achievement as demonstrated by writing a comprehensive test on a series of lessons. Each of the pre-test and post-tests were composed of three areas of questions to determine the:

(a) ability of the students to recall the names and labels of experimental equipment;
(b) ability of the student to comprehend scientific phenomenon that cannot be visually observed;
(c) ability of the students to use mathematical formulas to quantify experimental results and to
predict experimental outcomes.

1.7 The Specific Hypothesis

The experimental design used two independent groups to test the following hypothesis:

1. The overall mean achievement score of students after receiving an independent instruction review will be greater than the mean achievement scores of students tested after a traditional review.

The overall achievement score will be divided into three sub-test scores, which will be evaluated as corollaries of overall achievement.

(a) The mean score of the students tested on their recall of names of parts of scientific equipment after receiving an individual review will be greater than the mean score of students tested on their recall of names of parts of scientific equipment after receiving a traditional review.

(b) The mean score of students tested on their comprehension of the concept of the phenomenon related to experiments on the transfer of heat after receiving an individual review will be greater than the mean score of students tested after receiving a traditional review.
(c) The mean score of students tested on their ability to perform mathematical computations to quantify experimental results on experiments of the conductivity of metals, liquids and gases after receiving an individual review will be greater than the mean score of students tested after receiving a traditional review.

The methodology for conducting the experiments and recording the data is covered in Chapter III of this proposal.
CHAPTER II: REVIEW OF THE RELEVANT LITERATURE

2.1 Perspectives for Review

The literature review is organized according to the chronological order in which various researchers with an interest in independent learning conducted their studies and with a focus on the models that emerged from their research. Concerning chronology there are studies dating back to the 1920's that provide information on independent learning. There is, however, no attempt to show a direct correlation from author to author to indicate a single direction to the traditions of self-paced instruction. It is clear that there are many diverging branches within this field of research but an historical review of the research suggests that there is value in pursuing further research on independent instruction.

Research in the area of independent learning has contributed to a variety of models or teaching approaches often applied in classroom settings such as the Winnetka Plan, Personalized Instruction, Mastery Learning, DISTAR, Time on Task, Task Analysis and others. The review reflects differences in approaches and changes in theory, which have occurred over time.
2.2 The Winnetka Plan

The Winnetka Plan, Carlton Washburne (1922) and Chicago's Laboratory School (1926) had the following program components:

(a) courses were broken down into objectives;
(b) program objectives were cognitive and affective;
(c) instruction was organized into well defined units;
(d) continuous testing was employed during instruction;
(e) time for learning by the students was a variable.

Early attempts to individualize student programs, such as Carlton Washburne and Henry Morrison's proposal, evaluated the student's ability to master a particular set of program objectives. The students, therefore, competed against the course objectives rather than competing within the rank order of the classroom. This approach called for a fundamental change in educational objectives. All students in the class were assumed capable of meeting course objectives and competition between students was minimized. At a time when formal education was reserved for an elite group of students this was a radical departure from educational practice.

At that time, program objectives, according to Washburn, should reflect both cognitive and affective domains with
instruction organized into well defined units in a sequence designed to assist the student in mastering the unit objectives. Because the units were sequential, mastery of each unit was essential prior to proceeding to the next educational unit.

Each unit, in order, was tested using formative evaluation employing teacher-set tests. These tests were used to determine the students' extent of mastery of material and to provide feedback indicating areas where reinforcement or clarification were needed. On the basis of this feedback students were supplied with self-instructional practice material and teacher tutorials to assist small groups. Students were given an overall grade compared to the course objectives rather than against each other.

Finally these programs recognized that time was a variable of student achievement. The concept of self-paced instruction, which allowed time for students to learn each sequence while still being part of an overall classroom, was a major element in the Winnetka Plan.

2.3 Fred Keller Model

Fred Keller (1968) presented a model where key components of the Washburne and Morrison plans were further refined and placed within an operational setting. He proposed a "Personalized System of Instruction" where the teacher becomes a manager of each student's achievement to meet the
objectives of the school program.

The key components of his plan are:

(a) the teacher is the instructional manager of each student's progress;
(b) the course is broken down into small sequential units, which are mastered by the student in sequence;
(c) written communication between teacher and student is very highly stressed;
(d) proctors or tutors are used to provide educational correctives for students who require assistance in mastering the material.

Keller's model changed the role of the instructor from a dispenser of information to the manager of each student's mastery of the subject material. This places the teacher in a personal-social relationship with the student and stresses individual student achievement instead of the practice of grading the student according to rank order in the classroom.

Courses are broken down into short (1 week) units, which are mastered in sequential order by each student. The students were required to master a unit before proceeding to the following unit. Grading is based on the number of units mastered and there is no summative or comprehensive evaluation. Test formats are set by the instructors using multiple choice, essay type questions and true/false response to evaluate the students. Individual tutors and restudying techniques provide the educational correctives for students
who fail to master a unit's objectives.

Keller's process has value in redefining the role of the teacher, outlining the sequencing of units required for course preparation, and providing a self-paced student program where individual achievement is stressed. The weakness of the model lies in three areas. First, heavy reliance on written communication as the prior mode of teacher-student communication limits the ability of the teacher to adequately communicate course objectives. There is such a wide discrepancy between student abilities with the written communication mode of information transfer that it is difficult to keep students on a realistic time frame. Within the framework of this study, where the population is composed of slow learning students whose writing skills are their weakest area of communication, this aspect of the model presents a problem.

A second difficulty is the added resource of tutors. Traditionally tutors are a scarce resource in most secondary schools. Withdrawal assistance and remedial assistance are resources often separated from the actual classroom situation and are usually used to address deficits in the basic skill areas of reading and mathematics.

The third criticism is the lack of any form of a summative evaluation, which tie all the units together into a comprehensive course package. Adding up units for grading is acceptable in some courses, but in situations where one course
is a prerequisite for another program, there should be some form of summative evaluation to indicate possible student success in future studies.

2.4 Benjamin Bloom's Model

One of the most widely known and influential researchers to develop a framework for applying individual instruction within the classroom setting is Benjamin Bloom. (Bloom 1968, Block and Bloom 1973).

The key components, which Bloom added to the existing theoretical base of individual instruction, are:

(a) quality of instruction provided by the teacher;
(b) self-paced student instruction, where students were provided with the time they required to master units of course objectives;
(c) an evaluation system composed of formative evaluations of units and a comprehensive evaluation of a summative nature to determine overall comprehension;
(d) individual remedial instruction for students who fail unit mastery is integrated within the framework of group-based instruction.

The advantage of Bloom's model over Keller's model is that his design is used in group based instructional situations where time allowed for learning is fixed within a school timetable. In Bloom's application, strategies to
minimize the time students require to master units is
optimized. This can be accomplished by a wide variety of
teacher aids and by planning the course in a sequential and
hierarchical series of lesson units.

Bloom also divided the diagnostic progress tests into
two areas; Formative and Summative evaluations. "Formative
Evaluations" are designed to provide feedback information to
the instructor indicating the student's grasp of each unit's
objectives. On the basis of this information the teacher
prepares a set of alternative learning materials and
instructional correctives keyed to these evaluations. These
correctives are taught differently than group-based
instruction, as they are directed towards the deficits of the
individual student. The teacher designs remedial time within
the course and the student is given remedial assistance by the
teacher. The student then applies these correctives on his/her
own time, thus keeping up to the classroom timelines and
mastering units in sequence. For this study the instructional
correctives for the experimental group were composed of a
variety of audio visual aids and a self-paced student review
with a resource teacher managing the student's review program.
Reviews for the control group were taught by the classroom
teacher who used formative evaluations plus question and
answer techniques to focus reviews more specifically for the
needs of the students.

After a set number of units are completed the student
writes a summative evaluation or comprehensive test on all units. This, for Bloom, provides information for final grades that reflect student achievement of course objectives.

Bloom's design changes the role of the teacher, making him/her accountable for each individual student's progress. The teacher must develop an evaluation scheme that grades the student and also indicates to the instructor the areas of weakness of the students. The teacher must develop a program broken into sequential and hierarchical units and the teacher must use two teaching approaches during instruction. The first instructional strategy is applied to group-based instruction where the teacher must attempt to provide the clearest instructions on expectations of the program. For Bloom, the verbal communications between teacher and student is very important. Verbal communication is used to assist each student individually in understanding exactly what objectives he/she is required to master.

The second type of teacher instruction is an individualized approach in teaching the correctives to the students who have had difficulty mastering individual units. By using unique materials, instructional aids and alternate group instruction techniques the students will be able to master course objectives.

Under Bloom's model, the summative evaluation formed a criterion-referenced measurement of the student's overall comprehension. The research of Tindal et al. (1985) proposed
three main characteristics of criterion-referenced measurement:

(a) definition of a well-defined content domain;
(b) definition of valid performance criteria;
(c) development of procedures for generating appropriate sample tests.

A major advantage to developing a subject mastery criterion for the slow learning student was the removal of internal competition among the students. Students could proceed at different rates and compete against the content of the program, yet fulfill course requirements within a reasonable time frame.

Defining well specified content is relatively easy for science and mathematics based programs. These can be broken down into specific stages and directly related to everyday experiences or specific uses by the students. It is more difficult to define student performance criteria where students master a given context of material in a specified time frame. Reynold found that "multi-choice formats" are a viable method of assessing certain types of educational outcomes for mildly retarded adolescents" (Reynold, 1979, p. 331). He concluded that subjects, where procedures and answers were finite, could be measured by this testing format but open subjects such as English were very dependent on the subjectivity of the teacher and sample tests were less valid. He concluded by arguing that the validity of all tests for
students who were slow learners was valid only if the test questions were presented in the language used by the teacher who instructed the students. The questions on the tests must be similar in format to rehearsal questions used during instruction.

Applying Bloom's strategies within classrooms for slow learning students in this study highlighted two areas where application became difficult. First, constant testing for "formative" evaluations resulted in negative student feedback. These students tend to look for the "right" answers and disguise their deficits on written tests. They also will often avoid a section of study where they have difficulty, particularly in solving problems with definitive answers. A "formative" evaluation strategy, where testing is recorded on a continuum while the students are engaged in actual instruction or experimenting, would possibly yield the most accurate formative data. Computer drill and practice routines, where all steps are recorded for the teacher to review later and then apply educational correctives for future use, is one strategy to reduce negative student response to continuous testing.

Summative evaluations must be applied with caution. Students can achieve on small sequential units but show difficulty in recall after a short period of time. They also had difficulty integrating small units into an overall framework of a major objective and in applying these results
to unique situations. More research on the areas of evaluation strategies is required if Bloom's theories are to be successfully applied to the classroom instruction of slow learning students.

2.5 James Block and Peter Airasian

James Block and Peter Airasian provided valuable information in developing operating procedures for obtaining subject mastery (Block 1971). The key components of their research found to be most relevant in designing this study are:

(a) selection of subjects where prior knowledge is not required;
(b) selection of "closed subject" where precise objectives can be set and evaluated;
(c) division of subjects into small educational units;
(d) use of "formative" evaluation for feedback to identify educational correctives for individual students;
(e) use of alternate learning materials and alternate teaching strategies to help the individual student.

The selection of the science program on heat transfer is in keeping with the requirements of subjects for mastery learning, as outlined by Block and Bloom (1971). The lessons are sequentially based for both experimental work and for procedures used in quantifying the results. The subject is a "closed subject" composed of a finite set of ideas and the
content is both relevant to future studies and factual in nature (Bloom 1971). This allows for defined educational objectives and a very precise and explicit classroom teaching approach.

In her review of expectations of mildly handicapped students in mathematics, Dagmar Neal (1982) argues that a direct instruction, such as the method used in DISTAR, assisted the students in subject mastery and skill development:

"...direct instruction refers to teaching activities focused on academic matters whose goals are clear to students; time allocated for instruction is sufficient and content coverage is intensive; students' performance is monitored; questions are at a low cognitive level and produce many correct responses..." (p. 62).

Block found formative testing best suited for short unit tests with an item by item evaluation. However, for this study item by item evaluation posed difficulties with teacher-set evaluations. By clustering the units into three components of overall achievement; memory, comprehension of phenomenon and mathematical quantification of experimental results, the effect of invalid individual questions was reduced. The issue of internal validity for "formative" tests was addressed by using several questions in each area in order to accurately identify student comprehension of subject content. The use of completion questions, true/false response and multiple choice questions follows the procedures used by Bloom and Block in their research experiments on mastery.
learning.

It is in the teaching of the review lessons that the author has chosen one of Block's strategies; the use of alternate learning materials. Many authors and researchers agree that alternate learning materials have remedial value for students and two reasons, which are a reflection of our times, made this strategy very appropriate.

With new technologies including film strips, current ability to print small quantities of special learning materials and computers allow much greater scope for remedial application than in the past. Teachers are able to design unique approaches, using materials that are adapted to the specific needs of individual students. Schools now have specialists in audio-visual production and specialized resource personnel to assist the teachers in producing these materials. Procedure books, such as The Handbook for Teachers of Students with Learning Disabilities, (Ontario Ministry of Education, 1986), provide information for teachers on individualizing instruction, applying specific teaching strategies and understanding the special needs of students. The quantity and quality of special resource material have improved, while costs have declined. This allows the classroom teacher to design alternative instructional methods in very creative ways.
Airasian's comments highlight this study's objectives:

"One strategy for quickly identifying unmastered objectives is the use of special answer sheets which have a place for the student to mark his answer to each formative item, a list of remedial activities,... and a diagram showing the hierarchy of objectives for the course segment being evaluated" (p. 86).

Another benefit of the proposed study is the length of time students are allowed to learn each area and review deficits while remaining within a reasonable classroom timeframe. Many of these specialized materials can be used for self-paced instruction, administered in a resource room setting or used for home study by the student. This allows the student the time to do the required remediation while continuing his/her participation in the regular classroom instruction.

All educational objectives were clearly communicated to the students in writing and orally and they were directly related to the experiment and instruction previously done by the teacher.

The classroom instructional method was highlighted by the teacher's classroom demonstration. The students followed a particular process for each of the experiments, which are sequential and follow a logical order. Measurement and evaluation followed the same process for all three science and mathematical lessons. The review material used film-strips and slides to incorporate the "sequential process" students were to follow for quantifying results.
The evaluation objectives for student mastery were encompassed in an overall objective to comprehend those factors involved in the transfer of heat.

These objectives were taught within a series of relationships:

(a) heat transfer in solids, liquids and gases;
(b) the functional use of scientific equipment;
(c) applications of heat transfer;
(d) ability to quantify experimental results using a mathematical formula.

2.6 Individual Differences on the Rate of Learning

One of the criticisms of independent instruction has been the wide difference in the learning rate of students. Block (1971) believes the application of quality of instruction and the use of discriminatory tests to define which students have learning difficulties as a result of the school situation allow this difference in learning rate to be greatly reduced.

Therefore, techniques applied to reduce the effect of the learning environment along with appropriate instructional strategies should help students who learn slowly. An approach to using techniques to assist in this area was provided by H.S. Adelman's (1972) model and Adelman & Taylor (1983) application of television and computer media to enhance
motivation and stimulate attention span.

2.7 H.S. Adelman

H.S. Adelman's (1973) model adds two concepts to the previously described theoretical base for applying alternate teaching strategies for instructing students who learn slowly.

(a) The characteristics of the school setting in conjunction with the individual student characteristics have a major impact on the student performance.

(b) An instructional strategy applying a specialized teacher resource in a resource room concept can assist in helping students obtain subject mastery.

Similar to other authors, Adelman stresses "quality of instruction" as a key component for obtaining better subject mastery by slow learner students. His "Personalized Instruction" is similar to Keller's "Personalized System of Instruction", but Adelman's program isolates more variables within the instructional setting. These variables are characteristics within the school setting, which negatively affect the ability of slow learner students to achieve subject mastery. The combined effect of these characteristics influence the student's progress in his school program.

"Classrooms that are personalized usually have a wide variety of "centres", which are designed to foster and stimulate interest in learning; the teacher... emphasizes individualized programs for each youngster,... he attempts to minimize failure experiences as well as tedious and
boring activities" (Adelman, 1971, p. 119).

To apply Adelman's school settings and ecological variables to this study, the development of the film strips and video presentations were designed within the school facilities. The representation of equipment was identical to the equipment used by the student in his classroom lessons. All paper resources were direct representations of the in-school program using examples directly related to the experiments the students conducted and using vocabulary familiar to the student. The audio presentations were those developed and presented by the instructors. By designing the review material in this manner, the students were not faced with resources that were foreign to their direct experience. This was designed to reduce outside environmental factors, which would cause conflict with the students' learning characteristics.

Adelman's (1972) resource room strategy is summed up in his article on "The Resource Concept: Bigger Than a Room".

"... the resource room concept may be conceived as encompassing any function with the primary intent of helping others meet the education needs of all pupils, and especially problem pupils, wherever and whenever they are being instructed (p. 364)."

Adelman's resource room concept provides a means of obtaining specialist assistance within the staffing framework of the school. Keller's model employed tutors to assist students with difficulties. Adelman's model would employ
resource teacher specialists to assist the instructors with strategies to be applied within the regular classroom. These resource personnel would use a variety of instructional strategies for the remediation of student deficits. They would also have expertise in setting formative evaluations. By pinpointing the difficulties the students encounter, using formative tests and observations within the classroom, the appropriate educational correctives can be better identified and improved teaching strategies can be designed for the classroom teacher.

This concept was applied directly within this study. The layout of the computer resource room used for the non-traditional review allowed for the application of a variety of remediation strategies to be employed. The computer teacher and academic director were able to make valuable observations, which would allow the teacher to adjust his teaching strategy for remediation and select appropriate material for the students taking the review lessons. These observations will be discussed in Chapter V.

2.8 Alan Pavio

The research work of Alan Pavio (1975) on visual imagery was reviewed as auxiliary support for this study. Visual imagery is an important area for assisting learning disabled students to comprehend and apply concepts taught in school. The use of computer programs, where visual imagery is
displayed on the video monitor, is designed to assist students in mastering program objectives and course concepts. Many teaching strategies presently applied in the classroom employ visual imagery and learning disabled students benefit when this is used within the boundaries of the student's general knowledge.

Pavio's (1975) research articles were chosen for review of visual imagery because the research conclusions are most consistent with a dual-coding theory (Pavio 1971). Persons with learning disabilities often have difficulty coding verbal description, either written or oral, into a useful and reliable form of visual imagery. This is consistent with the findings of psycho-educational testing. Poor ability with verbal encoding is a characteristic used to label students as learning disabled.

Pavio's research aims, stated in his article on synchronic thinking, are very relevant for this study:

"...I will proceed by comparing and contrasting nonverbal imagery with verbal symbolic processes, on the assumption that human thinking involves a continuous interplay of both cognitive systems which, though interconnected, are functionally distinct" (p. 383).

The organization of this study and experiments conducted involve Adelman's stages of sequential organization. These stages are very similar to Pavio's research findings that "sequential organization of linguistic units" is required for information processing and that many individuals rely heavily
on visual information. There is still a necessity to have verbal encoding as a component in assimilating and understanding phenomena. This study aims to demonstrate that the use of an individual instruction approach can compensate for the deficiencies encountered by many students labelled as learning disabled and allow them to succeed within an integrated classroom setting.

2.9 Behavioral Characteristics of Students Who Learn Slowly

The literature was reviewed on the behavioral characteristics of students who require extra time and special programs to enhance their learning. Factors which would be observed by teachers during instruction and factors such as lack of motivation, hyper-activity, distractability and withdrawal from active participation in their programs are often evident with slower learning students. The design of the review program placed the students on a direct task interacting with the various forms of audio-visual media. Because each student could do their review on an independent basis there was reduced distraction from their peers. However, the instructors in the review room had to monitor students very carefully to ensure they were receiving constant feedback or the students would stop their review and interrupt others. Also, the equipment had to be in correct working order or the students became frustrated and confused with misinformation.

A few of the students in the study exhibited aggressive
behavior both during the lesson and practical experimentations and the independent review lessons. Dr. K.D. O'Leary (1984) outlined the Patterson treatment program applying the following principles where the student and teacher participate in a problem-solving approach. These students were counselled to determine their problems, generate alternate solutions to their undesirable activities and using positive reinforcement for good behavior. Most of these students performed very well during this study and there was a reduction in aggressive, hyper-active behavior.

Kurtz and Spiker (1976) identified many of the characteristics of the students who learn slowly, which apply to the sample group in this study. The students exhibit difficulty in spacial relationships, ability to perceive numerical relationships and "...the child fails to comprehend relationships of quantity, order, size, space and distance" (p. 621). Clearly these are skills required, if students are to succeed in enhancing basic knowledge and in applying their knowledge to vocational occupations. The authors perceived the successful teacher as one who "...is creative in use of concrete materials, skilled in breaking complex skills into smaller sequential units ... and who views clear auditory verbalizations ..." (p. 621) as the key components to successful teaching strategies for slow learner students. In their research they stressed the value of tape recorders and visual aids in helping the students grasp the significant
factors in the lessons.

Ray and Shotick (1976) concluded in their research that slower learning students had a significant deficit in their delayed recall measures. This would suggest the students would not do as well as their peers on comprehensive evaluations. Strategies to reinforce the significance of data and in making the data relevant to the individual student was posed as a possible assistance in helping the students overcome this deficit.

Torgensen (1977) proposed purposeful activity as a means to promote motivation, improved learning and improved retention. The important concepts he highlighted to be infused into the teaching strategies to overcome memory, attention and perceptual deficits were:

(a) students should be engaged in activities with high positive reinforcement;

(b) many students require special kinds of goal-directed activities which can be enhanced by the use of aids and creative teaching strategies;

(c) how to profit from rehearsal is a major skill area to develop for students who require extra time; controlling the rate of the stimuli, the sequential order of the material and the provision of rewards for success helped the students to develop more effective task strategies.

These behavioral factors and instructional strategies
were considered in the design of the review lessons for the experimental review group. Even though these principles were applied during the reviews with apparent success, a number of students used a form of withdrawal behavior, refusing to do the mathematical questions of any questions. Obviously there are deep-seated behavioral problems which some slow learner students exhibit which have to be addressed if improved learning is to be attained.

Shine et al. (1986) argues that fluency in the rate of learning is a measure worth studying for slow learner students:

"for mastery of most material, fluency is important. The other stages of behaviour, maintenance, application and adaptation all emphasize the importance of having a particular behaviour occur at some minimum rate before the methods of instruction appropriate for those stages are effective." (p. 551).

Fluency or the ease with which the students master material appears to have an impact on their comprehension and retention. By observing the student's behaviour during the instruction process the teacher can identify the fluency with which the student can grasp the important concepts in the lesson. Shine argues that these observations:

"...allow for the efficient, expedient quantification of what a teacher sees in the classroom, as the basis for selection for learning disabilities services. The procedures are reliable and valid" (p. 551).

These observations allow the teachers to apply specific remediation strategies and specialized materials when
designing the educational content for the review programs for the students taking part in this study.
CHAPTER III: METHODOLOGY

In this chapter the design, sample, treatment, data collection and analyses are described.

3.1. Experimental Design

The design used for this experiment compared the achievement scores of two groups of randomly assigned students. All interventions were done in intact classes. All the students participated in a series of lessons on the conductivity of heat, in metals, liquids and gases. The measurement of achievement was divided into three components:

(a) memory;
(b) comprehension of the phenomenon;
(c) mathematical quantification of experimental results;
(d) total score.

3.2 Sample & Population

The population defined for this experiment were vocational students enrolled in Basic Level programs.

Assignment of Students: The students were randomly assigned into two groups from one hundred and eighty six grade nine students. Eighty students were selected from the population and seventy agreed to participate. All seventy students were granted permission from parents/guardians to participate in the study. The students were between fourteen
and sixteen years of age, male and female, and have had similar educational profiles as indicated by their mathematics and English ability scores.

3.3 Procedures

Training and Testing: The teachers instructing the students have been involved in all aspects of lesson planning, preparation of the experiments and in planning for evaluations of students for this study. All tests used are of similar format to those used for regular classroom evaluations in the science program. The tests were formative in nature and designed to identify student weaknesses within the limits of the actual experiments performed. When planning the lesson the teachers used methods and approaches on lesson planning and preparation as outlined by the authors covered in the literature review section, Chapter II. Due to the nature of the experiment more extensive preparation than for the normal classroom lesson was required. The students were subjected to much more testing and increased evaluation and observation. Most of the extra time and preparation was required to ensure the test would be as valid as possible and the results would not be contaminated.

Assignment of Teachers: Figure 3.1 graphically outlines the assignment of students and teachers for the experiment. Two teachers provided the instruction during the experiment.
FIGURE 3.1

ASSIGNMENT OF STUDENTS AND TEACHERS

TEACHER A  

LESSON ONE  
(Conductivity of Heat)

CLASS #1  
Group  
A B

CLASS #2  
Group  
A B

CLASS #3  
Group  
A B

CLASS #4  
Group  
A B

TEACHER B

COMPREHENSIVE EVALUATION OF LESSON ONE

GROUP A STUDENTS  
Individual Review

GROUP B STUDENTS  
Traditional Review

POST-TEST AFTER REVIEW OF LESSON ONE

LESSON TWO SERIES OF INSTRUCTION  
(Conductivity of Liquids)
Both are experienced special education instructors and have advanced subject qualifications in science and special education qualifications for secondary school instruction of vocational students enrolled in basic level courses.

The two teachers and the academic studies director jointly designed the series of lessons and experiments on the topic of heat transfer. Appendix II provides outlines of all the lessons and the aims and objectives to be covered. A basic script was developed to assure a high degree of conformity between teacher styles and approaches to instruction. The researcher outlined the parameters of the lessons and supervised the design and constitution of all lesson plans.

Assignment within Class: Each class was randomly divided into two groups. The students assigned to group A in any class received an independent review lesson. Group B received a traditional teacher-directed review. The students remained in the same group for the entire study.

Both groups received the same evaluation tests after completion of their review lessons. These were conducted at specific data point collection intervals described in Section 3.5.

Assignment of Teachers: The two teachers alternated teaching lessons and review lessons to both groups. The teachers jointly prepared their lessons and followed a common lesson plan.

Lesson Approach for Study: The lessons were divided into
six areas. One mathematical and one experimental session formed a single lesson. After all these lessons were covered the total sample was given a comprehensive evaluation covering the total series of lessons.

Figure 3.2 outlines the flow that the students followed during the total time of the study. This figure illustrates various "Paths" and the tests which students took.

To complete the series of lessons and evaluations for this study nineteen days of instructional time were required. Each lesson period was one hour and twenty minutes in length and involved a teacher-directed lesson, a teacher demonstration of an experiment and a blackboard lesson reviewing the mathematical calculations. Students performed the experiments in small groups of two or three students with teacher assistance. Recognizing the length of period would be difficult. The basics were designed to incorporate a number of varied activities which included a teacher-directed component, laboratory work and question period. Appendix II covers the components of the review programs used for this study for both the individual and small group review.

3.4 Treatment

Instructional Areas: All classroom instruction took place in two identical science laboratories. Those students taking the teacher-directed review did their review in the science classroom. Students taking an individualized review
FIGURE 3.2

FLOW OF STUDENTS FOR EXPERIMENT

5 PERIODS OF INSTRUCTION

ALL STUDENT - LESSONS ON CONDUCTIVITY IN METALS

TEST #1 CONDUCTIVITY IN METALS

DATA COLLECTION FOR LESSON #1 - PRE-TEST

FORTY MINUTE REVIEW

INDIVIDUAL REVIEW GROUP A

SMALL GROUP REVIEW GROUP B

TEST #1A - CONDUCTIVITY IN METALS

DATA COLLECTION FOR LESSON #1A - POST-TEST

5 PERIODS OF INSTRUCTION

ALL STUDENTS - LESSONS ON CONDUCTIVITY OF LIQUIDS

TEST #2 EXPANSION OF LIQUIDS

DATA COLLECTION FOR LESSON #2 - PRE-TEST

FORTY MINUTE REVIEW

INDIVIDUAL REVIEW GROUP A

SMALL GROUP REVIEW GROUP B

TEST #2A EXPANSION OF LIQUIDS

DATA COLLECTION FOR LESSON #2A - POST-TEST

5 PERIODS OF INSTRUCTION

ALL STUDENTS - LESSONS ON EXPANSION OF GAS

TEST #3 EXPANSION OF GAS

DATA COLLECTION FOR LESSON #3 - PRE-TEST

FORTY MINUTE REVIEW

INDIVIDUAL REVIEW GROUP A

SMALL GROUP REVIEW GROUP B

TEST #3A EXPANSION OF GAS

DATA COLLECTION FOR LESSON #3A - POST-TEST

COMPREHENSIVE EVALUATION

DATA COLLECTION FOR ALL STUDENTS ON COMPREHENSIVE TEST

Footnote: Each lesson contained experimental work, and related mathematical instruction and review questions.
did their review in the computer room under supervision of the computer science instructor and the department head in charge of academic instruction.

All review lessons were conducted in a time period between 25 to 40 minutes and both the traditional review and the individual review covered exactly the same material and used the same examples for student rehearsal of subject material. All classes received identical length of presentation and time to do experiments and reviews. The teachers stressed the same areas and performed identical experiments.

Independent Study Review Procedures: The experimental group received individual review programs, composed of film strips, slides, video presentations and computer-assisted instruction. These review programs covered all components of the previously taught lessons. The students wrote a pre-test prior to the review lessons and took a post-test after the review lesson to allow for comparison of achievement scores.

The control group received a traditional teacher-directed review where all components of the science experiments and mathematical calculations were reviewed by the teacher in a small group setting. All students wrote the same pre-test and post-tests to allow for comparison of achievement scores.
Lesson Review Procedures: The teacher-directed review for this study consisted of:

(a) oral questioning of the students specifically on names and functions of parts of equipment used in the experiments;
(b) the display and naming of each part students are expected to remember;
(c) a review of the phenomenon of heat transfer using the chalkboard to explain the particular phenomenon to be understood;
(d) the development of the mathematical procedures used to quantify the results of the experiment;
(e) the teacher does sample questions on the chalkboard using the mathematical formula for that particular experiment;
(f) The students do rehearsal questions with the teacher providing assistance. The questions are taken up in the class. These questions use the same format and language of the test questions for student evaluation.

The individual review for the study consisted of:

(a) video presentations showing the science experiments as they were conducted by students in the classroom;
(b) a slide program, with audio support, to highlight names and functions of the science equipment used for the experiment;
(c) film strips with audio support displaying experimental set-ups and the procedures for measuring experimental phenomenon and quantifying results;
(d) an inter-active computer graphics drill and practice program to develop the students' ability to perform the mathematical calculations from examples of the experiments related to heat transfer. The audio tapes used identical scripts, using the voices of both classroom instructors. There was a random selection of teacher audio tapes, which the students used in the review lessons. Appendix II covers all procedures for the experiment.

The key authors referred to for designing the various components of the review lessons are as follows:
(a) individual programming components (Bloom, Carroll, Block);
(b) sequential instruction planning components (Bateman and Engleman);
(c) hierarchical and sequential instruction design (Adelman, Bloom);
(d) importance of visual imagery for comprehension of science phenomenon concepts (Pavio);
(e) design of formative tests and comprehensive evaluations.

3.5. Data Collection

Data Collection during Study: The total time for the experiment required nineteen (19) school days of instruction. There were seven points during the study where data were collected. These points are outlined in Figure 3.3.
### DATA COLLECTION

**FIGURE 3.3**

<table>
<thead>
<tr>
<th></th>
<th>TEST 1 TO 3</th>
<th>TEST 1a TO 3a</th>
<th>TEST 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>What test is to indicate</strong></td>
<td>Subject mastery after classroom instruction</td>
<td>Subject mastery after review of previous lesson</td>
<td>Overall Performance after study is completed</td>
</tr>
<tr>
<td><strong>Who is tested?</strong></td>
<td>All students in the study</td>
<td>All students in the study</td>
<td>All students in the study</td>
</tr>
<tr>
<td><strong>Type of test</strong></td>
<td>Formative evaluation (teacher set examination)</td>
<td>Formative evaluation (teacher set examination)</td>
<td>Comparison overall achievement of two groups</td>
</tr>
</tbody>
</table>
1. The test given to all students after each series of lessons evaluated the subject mastery of the students after the series of classroom lessons. The evaluation measured the components of memory, comprehension, mathematical computation and overall performance. All students undertook tests 1 to 3.

2. Students designated as Group A received an individual review (experimental group). Students designated Group B received a traditional review treatment (control).

3. The evaluation after the review lessons, Tests 1a to 3a, were designed to indicate the change in subject mastery of the students as a result of the review treatment.

4. The final Comprehensive Evaluation, Test 6, was used as the source of comparison between the two groups to test the fourth hypothesis in this study.

Data Collection after Lessons: The evaluation tests after each series of lessons were administered to all classes within their regular classroom time. These tests were formative tests covering all aspects of the previous lesson and were used to determine student subject mastery after the classroom instruction and after the review lessons.
Type of Testing Used: All students in the study were tested using questionnaire booklets developed by the classroom teachers (Appendix IV). The format of the questions used for evaluation were true/false, completion, multiple choice and mathematical calculation of results of experiments. Appendix IV provides samples of all tests used.

3.6 Comparisons within Groups

After completing the series of three lessons covering the experiments and three lessons covering the related mathematics on heat and conductivity all students in all four classes wrote a comprehensive examination.

Comparison of achievement scores was made using t-tests to evaluate the significant difference between the groups related to their subject mastery in the four areas:

- **Memory**: Retention of names of labels and an understanding of the function of the parts of the experimental equipment.
- **Comprehension**: The students' understanding of the scientific phenomena related to heat and conductivity.
- **Quantification**: The students' ability to use basic mathematics to quantify experimental results and make predictions of outcomes of experiments by using mathematical formulas.
Overall
Comprehension

The overall scores between the two groups on an additional separate teacher-set test compared significant differences of subject mastery. This was a final comprehensive teacher-set test taken at the end of the experiment.

3.7 Variables

The variables involved in this thesis are listed in Figure 3.4. The instruments used to evaluate these variables are covered in Section 3.5.3.

3.8 Internal and External Validity

There were nine major variables that could potentially threaten the internal validity of this study. These variables and the procedures adopted to reduce the effects of these variables are outlined below:

(a) Sex: Both male and female students were used in the study. The proportions of male and female were the same in both groups.

(b) School setting: All students participating in this study lived in the same geographic area and attended the same school.

(c) Achievement: Previous school performance and achievement on standardized tests of
English and mathematics were similar for both groups involved in the study.

(d) Ability to Use Computers:
All students had completed at least one credit course on use of microcomputers. They were familiar with drill and practice programs and programs containing graphic displays.

(e) Familiarity with Test Instruments:
The format of questions used, multiple-choice, true/false response and completions were standardized formats used by the students in their normal studies. Basic mathematical formulas had been used both in mathematics programs and in their technical studies programs.

(f) Teachers and Planners:
The teachers jointly developed the administrative experimental procedures and the review lessons. The key elements in the review lessons adapted for the computer-generated review were identical to those in the traditional review.

(g) Classroom Environment:
All four classes used the same laboratory facility for instruction. The two classrooms were back-to-back and shared equipment and resources. Both rooms had identical layouts.

(h) Randomized
All students had instruction by both
Instruction: teachers for different lessons and review lessons to reduce teacher bias effect.
SUMMARY OF ALL THE VARIABLES INCLUDED IN THIS STUDY

FIGURE 3.4

In all cases the variables were measured using a pencil and paper test. Items were scored right or wrong. Recall that the tests were teacher-made and constructed by participating teachers under the supervision of the principal investigator.

A: Memory related to Recall of Labels:
Memory of labels was defined as a measure of a subject's ability to recall names and functions of parts of equipment used in the test lessons.

B: Comprehension:
Comprehension was defined as the subject's ability to understand a scientific concept (conductivity). In order to evaluate depth of understanding the subject's ability to visualize the phenomenon and his/her ability to make generalized predictions related to the phenomenon were measured.

C: Mathematical Application of Formula (Symbology):
Mathematical use of formulas was defined as the subject's ability to quantify experimental results and to make predictions regarding the behaviour of the phenomenon under varying conditions.

D: Overall Performance:
The final comprehensive scores (test 7) compared the difference between students in Groups A and B.
3.9 Rationale for Design

All students included in this project were designated for basic level instruction by a Program and Review Committee.

The mathematics and English achievement scores of all students were obtained from standardized testing on an individually administered test. This ensured uniformity of measurement for the two test groups.

The dependent variables, related to achievement, were divided into four areas: memory, comprehension, mathematical calculations using formulas and overall performance as derived from a comprehensive evaluation. These variables were the same as those used for educational placement of students.

3.10 Research Hypotheses

The specific hypotheses given in Chapter I are stated in the form of research hypotheses as follows:

Overall Performance:

The mean achievement score, as determined from the comprehensive examination of students subjected to an individual review, will be less than the mean achievement score as determined from the comprehensive examinations of students subjected to a teacher-directed review.
1. Ability to Recall Names and Functions of Parts of Experimental Equipment used in Lessons:

The mean score of students, subjected to individual reviews relating to questions on recall of names and functions of parts of equipment, will be less than the mean score of students subjected to a teacher-directed review.

2. Ability to understand the Phenomena related to the Conductivity of Heat:

The mean score of students, subjected to individual review relating to their comprehension of the phenomena of conductivity of heat, will be less than the mean score of students subjected to a teacher-directed review.

3. Ability to Perform Mathematical Computations:

The mean score of students, subjected to individual reviews relating to their ability to perform the mathematical calculations to quantify conductivity of heat, will be less than the mean score of students subjected to a teacher-directed review.

The scores (dependent variables) representing ability to use mathematical formulas will be obtained from Part C of the comprehensive evaluation Test 7.
4.1 Results

The purpose of the present study was to examine the effects of specific treatments, namely individual versus traditional reviews for secondary vocational school students. The design called for randomly assigning students to two groups. One group received specialized instruction on the individual review process and the other group received the traditional teacher-directed review. The students participated in a series of lessons on the conductivity of heat in metals, liquids and gases. All students were tested for achievement gains on pre- and post-tests. Consequently, what follows in this chapter is a presentation of the results.

It should be noted that the number of students in each group changes in some of the tables. This is the result of students being absent from school during the days when the experiment was being conducted. The experiment lasted a total of 19 days.

In addition it is very difficult to keep this number of students on task due to unforeseen school interruptions. This was especially true in running the experiment in May with only a few weeks before the end of the school year and with many demands on the students to complete assignments and projects. However, given the nature of vocational schools, it is not unreasonable for students to be away from school because of
Work Experience and special projects. It was felt by the author that no special pressure should be put on the students by making the participation too mandatory or taking precedence over all other school activities or the students could become negative toward the experiment. Another problem was the negative reaction of many students to such intensive testing and such a demanding program structure. Some students, who did not get instant positive results, wished to leave the project or skip classes.

First, the means, standard deviations and the ranges on the pre-tests and post-tests for the two groups for each component of the experiment are given. Second, the results of both the paired (correlated) and independent t-tests are presented.

The purpose of these tests is to determine whether there are significant mean differences across the tests and between groups. Third, for exploratory purposes, the results of the correlational analyses are summarized.

4.2 Descriptive Statistics

Tables 1 through 3 present the means, standard deviations and the ranges for each of the instruments used for this study. The tables summarize the results by pre-test and post-test scores separately for each component: heat, gas, and liquid. In addition, the overall mean achievement scores are given for the experimental group.
In terms of test score variation, there seems to be more variation in the post-test scores than in the pre-test scores. The experimental group showed higher maximum scores than the control group.

4.3 Correlated t-tests

In this section the results of the correlated (paired) t-tests are given. The purpose of this statistical procedure is to determine if there are statistically significant mean differences between the pre-test and post-tests for each individual group. The significance level (alpha) was set at .05. Because the project hypothesized an increase in scores for the experimental group a single-tailed t-test was utilized.

Tables 4 to 9 summarize the results of the t-tests. The results reveal that in all cases the means increased from the pre- to the post-test. For the experimental group only two t-tests did not reach the chosen significance level. For the control group all except one t-test were significant - one memory test on the gas component. These results are significant in demonstrating that a sequentially structured approach to instruction may improve subject mastery.

The two t-tests in the experimental group and the t-test in the control group did not reach the accepted significance level. In summary, each of the two groups significantly increased their respective scores between the first and second
test administrations.

4.4 Independent t-tests

In order to determine if there were any statistically significant differences between the experimental and control groups test scores, independent t-tests were performed. The t-tests were run separately for pre-test and post-testing sessions. The results reveal that there were no statistically significant mean differences between the experimental and control groups on any pre-tests, (i.e. math, comprehension and memory). These results are displayed by tables 10, 11 & 12.

4.5 Correlation Analyses

In this section, the results of the Pearson's correlation are given. Table 14 on the following pages display these results. It was of importance to determine how the various test scores correlate with each other. Separate correlations were calculated for the control and experimental groups. The results reveal that the intercorrelations ranged from -.20 (Comprehension 1 Pre-test with Mathematics 1 Pre-test for the control group) to +.76 (Mathematics 1 Pre-test with Memory 2 Pre-test for the control group).

Interestingly, there appears to be more fluctuation in the intercorrelations for the experimental group. In general, there appears to be no trend that emerges from the results of the correlational analyses.
4.6 Summary

The means and standard deviations for the comprehensive evaluation (final tests) for memory, comprehension and mathematics are given in Table 13. The means on comprehension and mathematics were significantly higher for the control group receiving teacher-directed review. For the memory evaluation only a slight difference between the two means occurred.

Comparing table 13 with tables 1 to 3 shows the mean scores for memory changed from a low of 5.2 (Experimental Group Table 1 to 21 on Comprehension Table 13). This would indicate the constant repetition of naming the parts and their factors was an effective instructional strategy.

The mean scores for the Comprehension and Mathematics areas on the Comprehensive remained similar for the experimental group and varied for the control group for mean 8.9 (table 2 Control Group to 36.6) for Comprehensive. This may indicate that an entire course of several lessons may produce improvement in memory and comprehension with an extended time-frame for the total course of study.

There appears to have been no comparable improvement in the mathematics area after the final lessons. The reasons have been addressed previously in this report.

On examination of the ranges (minimum/maximum scores), it is evident that there is a great deal of variation for both
groups in all three subjects. This also becomes more evident when we examine the standard deviation over the three lists.

There was no significant improvement in each of the three corollary areas of memory, comprehension or mathematics. Therefore, the three corollaries are also rejected. It is of significance that the students in the experimental group obtained the same degree of improvement in their overall achievement and in their improvement in the areas of memory, comprehension and mathematics as did the students who had the teacher-led review. This suggests there may be educational value in applying individual study methods and individual review techniques to a segment of the vocational school population who may be motivated by using independent study methods. Chapter V will further discuss the conclusions of the research findings and make arguments for the educational value of this research.
### TABLE 1
MEANS (X), STANDARD DEVIATIONS (S.D.) AND RANGES FOR CONDUCTIVITY OF METALS

<table>
<thead>
<tr>
<th>Variable</th>
<th>Test</th>
<th>Group</th>
<th>n</th>
<th>X</th>
<th>S.D.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Memory</td>
<td>Pre</td>
<td>E</td>
<td>31</td>
<td>5.20</td>
<td>2.40</td>
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<td></td>
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<td>2.40</td>
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<tr>
<td></td>
<td>Post</td>
<td>E</td>
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<td>24.00</td>
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<td>7.00</td>
<td>25.00</td>
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<td>4.20</td>
<td>12.00</td>
<td>24.00</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>E</td>
<td>29</td>
<td>21.20</td>
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<td></td>
<td>C</td>
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<td>8.00</td>
<td>7.50</td>
<td>0.00</td>
<td>18.00</td>
</tr>
</tbody>
</table>

*E = Experimental Group; C = Control Group

Zero score reflects a motivation problem where students refused to complete the test.
### TABLE 2

**MEANS (X), STANDARD DEVIATIONS (S.D.) AND RANGES FOR EXPANSION OF LIQUIDS**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Test</th>
<th>Group</th>
<th>n</th>
<th>X</th>
<th>S.D.</th>
<th>Min.</th>
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<td>Post</td>
<td>E</td>
<td>29</td>
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<td>16</td>
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*E = Experimental Group; C = Control Group*
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<th>Max.</th>
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</table>

*E = Experimental Group; C = Control Group
### TABLE 4

RESULTS OF THE CORRELATED t-TESTS
FOR CONDUCTIVITY OF METALS

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<tr>
<th>Variable</th>
<th>Test</th>
<th>Group</th>
<th>n</th>
<th>X</th>
<th>S.D.</th>
<th>t-value</th>
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<tbody>
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<td>&lt;0.0001</td>
</tr>
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<td>Pre</td>
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### TABLE 5

RESULTS OF THE CORRELATED t-TESTS
FOR CONDUCTIVITY OF METALS

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<th>Variable</th>
<th>Test</th>
<th>Group</th>
<th>n</th>
<th>X</th>
<th>S.D.</th>
<th>t-value</th>
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* denotes (NS)
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RESULTS OF THE CORRELATED t-TESTS
FOR EXPANSION OF LIQUIDS

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* denotes (NS)
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MEANS (X), STANDARD DEVIATIONS (S.D.) AND t-VALUES FOR CONDUCTIVITY OF METALS ACROSS GROUPS

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* denotes (NS)
TABLE 13
MEANS (X), STANDARD DEVIATIONS (S.D.) AND RANGES
FOR FINAL TESTS ACROSS GROUPS

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### TABLE 14

**INTER-CORRELATIONS FOR PRE-TESTS AND POST-TESTS FOR BOTH THE EXPERIMENTAL AND CONTROL GROUPS FOR CONDUCTIVITY OF METALS**

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CHAPTER V: CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS

5.1 Summary of Results

The purpose of this study was to examine the effects on achievement scores of individual and traditional reviews on a group of secondary vocational school students. In this chapter, the major findings and conclusions are presented along with some discussion about the findings.

First, all hypotheses were rejected. The control group in general had slightly higher mean scores than their counterparts in the experimental group. Possibly students are more familiar with teacher-directed reviews. Because they were following a familiar instructional format, students in the control group received higher scores than students in the experimental group who had to learn a new instructional strategy. Another possible factor in this outcome is that students are accustomed to having their questions answered orally instead of having to search out their own answers, which was a new situation for the experimental group. Lastly, due to design and timetabling, the experimental group was usually twelve to fifteen students whereas the teacher-directed review was eight to ten students, allowing for a more direct response to student difficulties than would normally be the case.
In terms of test score variation, there seems to be more variation in the post-test scores than in the pre-test scores. An examination of the minimum and maximum scores offers some explanation. In most cases the maximum scores increased substantially over the two testing periods. This probably means both groups increased their knowledge base as a result of the experience. This was also expected and would be significant. The highly structured and sequential presentation of material and the teacher use of the formative testing allowed for improvements in instruction during the experiment, a confirmation of Block and Bloom’s (1974) findings. It is also possible that there was a Hawthorne Effect on the students and teachers by being part of an experiment. This would tend to increase the effort and motivation of many students who have potential but do not always work to that level. The structuring and sequential process would also improve teacher performance, allowing them to plan for many potential student misunderstandings and build in re-teaching strategies.

Secondly, the experimental group showed higher maximum scores than the control group. As the students in the experimental group became familiar with the independent review process, those highly motivated to succeed could design their own review for their own needs. The individual review may also be appealing and motivating for the students who enjoyed working on their own rather than in a lock step classroom
manner. All students had equal times for the review lessons.

5.2 Discussion

All students showed significant improvement in their ability to recall names and functions of the science equipment as a result of both independent study techniques and teacher-directed reviews. The testing of memory questions consistently received the highest mean scores from both groups of students. This may be attributed to the following factors. First, much of the equipment was repeatedly used for the total length of the experiment so there was considerable reinforcement. Second, only three or four pieces of new equipment were added to each experiment and the design of equipment often provides clues to the function of the equipment. Finally, students have been studying science, using laboratory equipment in grades 6, 7 and 8 and it would be expected that there would be some background knowledge to identify the equipment.

Experience in teaching within the school, however, has often demonstrated an inability of the students to effectively retrieve data from memory for names and functions of tools within their technical subjects. The results of the students on retrieval of names from memory still demonstrated that many students have deficiencies in this area and particularly in their inability to write the data accurately on the test. The students often knew the names and put them on the drawings in
incorrect order, suggesting they are memorizing words without comprehension and that they have not effectively memorized the names of parts by association with a visual image of the part.

During questioning and discussion, the students often expressed frustration at being unable to describe the functions of the parts of the equipment in words or written expression. A guided questioning strategy by the instructors would often assist them in focusing their response to a correct answer. The students appear to lack strategies to process the data without prompting. It was observed by the instructors that the students in the teacher-directed group preferred to answer the questions on memory when presented in an oral question form to the group, rather than one-on-one drill. The students' desire to avoid "failure" by giving a wrong answer provides a possible explanation to this observation. Within a group they are not singled out. Although it was stressed through instruction that developing a strategy for learning the material was a main objective, the students continually demonstrated a strong desire to obtain a "right" answer and the format of the memory questions was designed for right and wrong answers, which reinforced this strongly held belief.

Another observation was the speed with which the students answered the questions. Almost all finished well before the allotted time for this area of testing and demonstrated little reflection or review of previously
completed questions. Although correct spelling was clearly stated as not important, many students repeatedly asked how to spell the labelled parts of the diagrams. It is possible they were seeking some form of response from the instructors as to whether this was a correct answer, which suggests that their fears of being "wrong" were hard to dispel.

5.3 Ability of Students to Improve Comprehension

The students did not show significant improvement in their ability to comprehend the science phenomenon studies as a result of independent study techniques. In the completion questions the list of words was provided, yet there were still questions regarding the importance of correct spelling. Even with this list many student responses were copied down incorrectly. On the completion questions students often made corrections to their initial response, possibly demonstrating a lack of conviction in their comprehension. This section required an ability to read a full sentence with accuracy and comprehension. The sentences contained the technical terms used during the lessons and often clues to the correct answer were provided within the question. All students had done rehearsal on similar questions during the lessons and the final test questions came from the rehearsal questions. Possibly the instructors should have provided more time concerning strategies on how to answer these types of questions for the students who were very slow readers.
The rehearsal of completion type questions for the independent study group were the same as those used for the teacher-directed group. The questions used a paper and pencil format but each question had a film-strip name and frame number, which provided the data to which the student could refer. After completion of the question the students were provided with a correct answer sheet for the rehearsal completion questions. The students in this group responded very favourably to this strategy of review and were very diligent in filling in the questions and referring to the film-strips for the answers.

The true/false questions also required the ability to read a sentence with comprehension. Unlike the completion questions the students rarely changed their initial response or re-read their answers. In many cases they would "guess" if unsure. Students were very familiar with true/false formats and in other subjects have often been instructed to guess if they were unsure. This limits the value of true/false question formats for formative evaluations as instructors will not be able to evaluate how well the student is comprehending the material. The inability to read with accuracy would be expected to limit the ability of the poor reader in answering these questions accurately. Possibly having these questions on tape and allowing the students to listen to the questions as well as read the questions would provide additional clues, which would aid comprehension.
During oral rehearsal for the true/false questions for the teacher-directed review, it was observed how willingly the students would answer these questions when presented orally to the group. It may be that this instructional strategy gave a false sense of competence to the students and made them feel these were easy questions.

The students doing the drill and practice true/false rehearsal on the computer demonstrated no improvement over the teacher-directed review even though they had individual feedback and reinforcement. They were allowed to do several drill and practice computer questions but many students would spend a minimum time on this review station. After being given positive reinforcement for a few questions the weaker students would leave this area stating that they got the right answers and knew that area of questioning.

5.4 Ability of Students to Improve Mathematical Calculation

The students in the independent review group improved their ability to master the mathematical computation questions approximately equal to the teacher-directed group. However, this was the weakest area of subject mastery and conceptual understanding for all students. The mean scores did not differ between groups and across teacher-set tests. Even with continual rehearsal, one-on-one instruction and direct association of the data gathered from the experiments to make the data relevant, the students failed to produce improved
comprehension of the value of mathematics to quantify results. The study highlighted the difficulties the students have in mastering mathematical concepts and developing procedures for solving mathematical problems.

Comparing Table 1 and Table 5 experimental groups for the Mathematical Means and Standard Deviations shows a great deal of difference. The Means vary (6.3 vs. 3.9) and the S.D. vary (11.2 vs. 3.5) with similar numbers. However, for the post-tests the results are very similar (Mean 5.2 vs. 5.1 and S.D. 6.2 vs. 6.2). The students' refusal to attempt mathematical problems and their lack of confidence in their answers demonstrate their inability to master both process and procedures with any consistency. This is borne out in everyday teacher experience, as the students often seem to lose the ability to do the mathematical work they appeared to have mastered a short time previously. The tables also show that post-test results can be lower than pre-test results for the mathematical evaluations. Some of this may be due to students "giving up" when they cannot master the concept or procedures. Also, some of the students found the nineteen days a long time to maintain interest in the study. The constant testing was one of the areas of complaint by the students.

The teacher-directed review relied extensively on a chalkboard strategy to develop the method of approach to quantifying the results of the experimental data using mathematics. The teacher then directed a group question and
answer session to clarify the procedure and paper and pencil rehearsal questions were then done by the students. While the students were doing the questions they were given individual assistance by the teacher on how to approach the problem and on what the data measured actually represented. The work was checked in class and discussion was directed by the teacher. After the students finished these questions they were reviewed and corrected. All students used calculators and were given a chart, outlining in point form how to proceed with applying the formulas in a step by step manner.

The independent study group had a film-strip with audio backup demonstrating the step by step manner to apply the formulas. Each student reviewed the film-strip and proceeded to the computer graphics station. The experiment was developed by a computer graphics program and each data point was highlighted. The data was then applied to the formula and the students answered computer questions that gave them direct feedback to their response. The students used the same review questions as the teacher-directed review group. While doing the rehearsal questions the students could refer to the film-strip and the computer programs to assist them in mastering the questions.

Almost all students were successful in doing review questions and completing the computer drill and practice sessions. The students doing the independent review were very positive about this procedure and were very willing to
complete all assignments. Many students felt the method was very helpful to them and expressed an interest in having it used in their regular studies programs.

It was surprising to find such poor response to the mathematical questions on the testing for both groups. In the early testing many students refused to even try the mathematical questions, but as the study proceeded more students attempted to answer the questions related to mathematics.

The following observations made during the study relate to the mathematical lessons and testing results:

(a) Many students were able to do the rehearsal questions yet refused to even try the questions on the tests. They expressed a fear of being "wrong" or "I can't do mathematics".

(b) Even though they had considerable instruction on the procedure to follow, when tested they could not remember the sequence of steps to use.

(c) A number of students would write down the answer refusing to follow the step by step method. It is probable they do not wish to be "wrong" a number of times on each question. The students also have a strong belief that as long as they get the "right" answer they do not have to do further review or receive further criticism.

(d) Many students could not do the simple division
required even with the use of the calculator.

(e) As the study proceeded the students often got the three formulas confused. They displayed an inability to comprehend that the formulas had a specific purpose for that particular experiment.

(f) Many students were unable to comprehend the significance of the units assigned to the data. They were unable to comprehend the significance of a measurement assigned in centimeters, temperature in degrees and volume as a cubic measure. As a group almost all students appear to lack a visual image of the value of the data measured during the experiment.

The students refused to attempt mathematical problems and their lack of confidence in their answers indicates major difficulties in the areas of quantifying results and understanding the significance of mathematical data. The independent study program was deemed to be valuable in motivating students to try a new approach but a far more sophisticated procedure and much more research is required to make significant improvements in the students' ability to master the process involved in quantifying data using a formula.
5.5 Ability of Students to Improve Overall Mean Score

Upon comparing the post-test results the students in the independent study group failed to register significantly higher mean scores on the comprehensive evaluation than the teacher-directed study group. The purpose of this statistical procedure was to determine if there were statistically significant mean differences between the pre- and the post-tests for each individual group. The significance level (alpha) was set at the .05 level.

5.6 Effectiveness of Specialized Resource Materials

The teacher-directed student group was very familiar with their particular form of review and welcomed the chance to ask questions for clarification during the review. They were very receptive to one-on-one assistance when working with the mathematical questions. This is not surprising as they have most of their instruction presented in this strategy for both review and classroom lessons.

The students in the independent study group were able to readily apply themselves to using the four different forms of resource material. The following observations were made during the review sessions:

(a) After the first lesson the students showed a preference for slide presentations and the film-strip presentations with audio support.

(b) When attempting the paper and pencil review
questions they consistently referred to the film-strips for reference, particularly on the procedures for doing the mathematical questions.

(c) After one or two review sessions many students switched their preference of resource to the computer stations and the computer drill and practice questions. However, on the computer stations they experienced difficulty choosing the correct formula on the final review. This program could possibly be rewritten to avoid confusion. Computer instructions must be very clear or students will have a harder time compensating for errors than they appear to have on paper resource materials.

(d) The students doing independent study tended to ask fewer questions of instructors when doing the experiments than those students on teacher-directed reviews. The independent study students were more apt to refer to the aid sheets and search out answers for themselves.

(e) The students doing the independent study were very positive about the experience, claiming it was helpful in understanding the work. This positive attitude, however, did not improve the students' test scores.

Although the increased motivation and interest of
students is a subjective measure, the application of specific resource material is worth further investigation. There is considerable support for this approach in the literature and one of the objectives of the study in developing increased visual imagery by association of names and functions of equipment with direct pictorial representations did appear to motivate the students.

5.7 Effectiveness of Sequential and Hierarchical Instruction

There was no specific evaluation of the effectiveness of organizing the lessons and reviews in this format. The weight of evidence from the literature, (Block, 1971 & 1974; Bloom and Block, 1971; Clark et al. 1984; Lufting, 1982 and Adelman, 1976) would suggest the independent strategies used in the experiment are valuable in assisting subject mastery for all students. Both groups of students in the study obtained an overall increase in subject mean scores on the comprehensive test and some of this success may be attributed to the design of lesson material in an hierarchical and sequential format.

The design of the visual aids and computer programs required organization of the material in a sequential nature. Almost all courses taught at the school follow strategies using methods of presentation that follow a sequential lesson format.
5.8 Effectiveness of Special Resource Room

The resource room layout was based on research work done by H.S. Adelman (1972). He claimed the development of specific resources and a resource room designed to facilitate different instructional strategies improved the subject mastery of many slow learner students. This study failed to replicate his results.

Adelman's application of a specifically designed resource room was applied to students for a much longer time than in this study; however, observation during this study would not justify extensive expenditure in this direction. The best way to use special resource material may be to situate it within the classroom environment, for use by the teacher, with students that the teacher observes would benefit from independent study. Some students responded very favourably to independent review strategies but much more research would be required to ascertain what type of students benefit from independent study strategies.

5.9 Limitation of Study

The following limitations encountered during the study should be taken into consideration before the study results can be generalized to the vocational student population.

This study was conducted in the last two weeks of May, 1987. This proved to be a difficult time to carry out a school study involving over half the grade 9 student body. The
students were preparing for final testing prior to the completion of their first year of high school and many students were pressured by limited time to finish shop projects. There are also a significant number of activities crowded into the final few weeks of school, such as sports events, field trips and outdoor activity programs. These conflicting interests and pressures often made it difficult for the students to be in all sessions of the lessons and reviews.

The original plan was to complete all lessons and reviews in fourteen days but this was not enough time for the study. Nineteen days were required and during this period many students lost interest and motivation as the study made increasing demands on their time and required them to drop out of other school activities.

The constant test-retest model was clearly a limitation for this study. This form of testing took a great deal of time, seven tests in nineteen days, and many students resisted the frequent testing sessions. Many of the students in the study have not been successful at writing tests and a more subjective type of evaluation would possibly provide more significant evaluations than the model used for this study.

Many articles in the literature review recorded positive results for independent instruction. This was generally true for the areas of memory and comprehension in this study. The ability to quantify results in a mathematical form and make
predictions was lower than many of the research studies. However, educational testing in mathematics is often derived directly from basic comprehension of mathematical questions. Having to apply experimental data from testing to mathematical formulas and make predictions of future results is more complex and, therefore, the lower student scores in this area may be an accurate indication of the students' ability in these areas.

5.10 Suggestions for Further Research

The results of this study did not indicate that independent review strategies had any advantage over teacher-directed reviews. There is a need to do further research on independent study to be used in situations where students cannot be provided with individual teacher attention. These situations can be home study, summer school when teacher resources are more limited and for credit make-up courses that are not offered due to low enrolment.

The following are suggestions, which may assist in the design and with procedures for further research, focusing on the value of independent study techniques for students, participating in this study.

1. Follow-up studies should include a comprehensive training program for the students on how to proceed with independent study strategies. The students in the study require more time, practice and instruction to develop
independent study skills than was provided for in this study. Many students have a history of lack of confidence in adapting to new situations, which was evident during the study.

2. Follow-up studies must develop more sophisticated testing techniques than those applied to this study. Although the literature indicated the techniques used were valid, it is possible the students tested in the studies done in the literature review had more success at writing tests and examinations than vocational students. A form of continuous testing while the students are involved in the programs would be one strategy of evaluation worth pursuing.

The most accurate form of response from vocational students appeared to be verbal questioning. Verbal questioning strategies, particularly with prompting from the instructor, may indicate more accurately how much comprehension the student really has mastered. The development of valid verbal/response testing to replace paper and pencil testing would be of value in assessing a more accurate reading of student knowledge.

3. Further research should consider a longitudinal study format. Comparing four or five classes over a full program may provide the students with time to develop the competencies required for independent study techniques. This study, conducted in nineteen days, put considerable pressure on the students to complete work when they were also in the last few weeks of evaluations for their regular program.
4. Some students responded well to the independent study format and a cursory examination of the scores of these students indicated they were the more capable students in terms of having mastered basic skills. Follow-up studies to identify the characteristics of vocational students who could benefit from independent study would be of value for the design of school programs.

5. This study, as do most research studies of instructional methods, focuses on the basic skill areas of mathematics, reading and writing. This is the weakest area of ability for vocational students and follow-up studies may benefit from testing the ability of students to master vocational subject materials. This is the area of highest motivation and success for these students and applying independent study techniques to these areas may be of value to teachers in vocational programs. Although they are not a homogeneous population, this relates to major areas of weakness in student populations identified as "learning disabled".

6. Although the teachers attempted to be impartial, it may be argued that it is in their best interest to have teacher-directed studies superior to independent study. Teachers may have stressed the importance of their review subjectively and because students are committed to the teacher they may have responded better than they normally would have under classroom circumstances. Future designs for research
should facilitate neutrality on the part of the teachers.


APPENDIX I

EXAMPLES OF PSYCHO-EDUCATIONAL ASSESSMENT EVALUATIONS OF SAMPLE AND POPULATION

(a) Psycho-educational assessment instruments used to assess students for vocational schools

(b) Examples of independent assessment summary test results sheets

(c) Example of an admission placement letter
Psycho-Educational Testing Instruments used for Vocational Admission:

(i) WISC-R - this is an individual student assessment administered by a qualified school psychologist. This is reported on the form as:

Fs - full scale I.Q.
V - verbal I.Q.
P - Performance

VERBAL TESTS
Information
Similarities
Arithmetic
Vocabulary
Comprehension
Digit Span

PERFORMANCE TESTS
Picture completion
Picture arrangement
Block Design
Object assembly
Coding

2. C.C.A.T. - This is often administered as a group test and is reported in stanines:

v = verbal; p = performance; s = subtests full

3. Monroe Sherman Reading Aptitude and Achievement Test:
This is scored in grade equivalents

4. W.R.A.T. - this is an achievement test for grading of:
spelling; reading; arithmetic
This is scored in grade equivalents

5. Sentence completion tests and the Raven Progressive Matrices are often used by psychologists doing individual assessments.
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SUMMARY OF TEST RESULTS

FOR PSYCHOLOGICAL DEPARTMENT FILE ONLY

Name
Birthdate: __________________

Date

School

Placement

Verbal Perf.

Full

C.A.  M.A.  I.Q.

I.Q.  I.Q.

Previous Tests

WPPSI Verbal & Visumotor Mid-Average 1976

WISC-R Non-Verbal Average Range

Wide Range Achievement Test Reading

Verbal Low Average

Spelling - grade equivalent

Arithmetic - grade equivalent

Present Test(s)

Wechsler Intelligence

Scale for Children

(revised)

Verbal tests

Information

Similarities

Scaled scores Arithmetic of Ten are average

Vocabulary

Comprehension (Digit Span)

Performance Tests

Picture completion

Picture arrangement

Block design

Object assembly

Coding

(Mazes)
STUDENT POPULATION PROFILE

Headings for describing Population Data

Student Name: Names of all students. Grouped by class and by treatment A or B

Student Number: Cross referenced to data collection sheets

Age: Age of student in years and months

Sex: Male or Female

Exceptionality: Slow Leaner - (SL)

Label: General Learning Disabled (GLD)

Withdrawal Assistance (W)

Behavioral (B)

Specific Learning Disability (SLD)

Opportunity Class (Int Op)

IGLD-Intermediate General Learning Disabled Classroom Setting

Special Reading Class (SRC)

English as a Second Language (ESL)

Communications Exceptionality (Exc-com)

Intellectual Exceptionality (Exc-In)

W.I.S.C. Scores (in percentiles)

Full Score (FS)

Verbal (V)

Performance (P)

C.A.A.T. (in stainines)

Verbal (v)

Quantitative (q)

Spacial (s)

Grade equivalent scores

Reading (R)

Mathematics (M)

(grade level)
APPENDIX II

CORRELATION OF PSYCHO-EDUCATIONAL VALUATION SCORES FOR STUDENTS PARTICIPATING IN THE STUDY

(A) Background to material development

(B) Description and examples of review materials:
   (i) video presentation
   (ii) slide program
   (iii) film-strip program
   (iv) drill and practice computer review
   (v) paper and pencil review

(C) Organizational chart of review room layout
(A) Background to Review Material Development:

The individual review was designed to consolidate student knowledge on all aspects of the science experiments and related mathematics. The formative tests provided data to assist in determining the areas of weakness of each student and to direct him to review situations that would apply the appropriate educational correctives. All review material provided visual, audio and drill and practice components. The reviews were designed to be situational to the specific classrooms and to be as focused as possible for the slow learner student.

Description of Review Material:

(i) Video presentation

*Educational purpose ...

Each experiment was video taped with an auditory explanation focusing on "how to" conduct the experiment and what to observe. The experiment was done in the actual science laboratory and using identical equipment as that used by the students when they did the experiment. Video techniques, using close-ups and slow motion, were employed in order to focus on the critical experimental observations. Each video was four to five minutes in length.

*Educational purpose ... this review provided a
general overview of the experiment and assisted the student with his recall of his observations when he conducted the experiment.

(ii) Slide Program:

Purpose of slide program - to focus the student's concentration on the names of parts of scientific equipment, the organization of experimental set-up and the functional use of each piece of equipment. A series of slides were organized showing each part of equipment and the set-up of the experimental equipment. An audio tape was made to sequence with the slide presentation which the student reviewed. The audio tapes were made by the two instructors and they focused their comments on the review of the scientific equipment and the experimental set-up.

A slide presentation could have between 20-30 slides and audio comment. The choice of whether a student received a long presentation or a short one was made as a result of the memory component from his formative tests.

The slide program usually required four to seven minutes for a student review.
(iii) Film-strip Program:

**Purpose of Film-strip Review** - each experiment had a film-strip, which outlined a review of the experimental set-up focusing on the measurements of time, temperature and length, which the students were to record. An audio review tape was sequenced to explain "how to" take the measurements and the "procedures" to record the observations.

The review program then proceeded to a step-by-step review with audio back-up of each step in the procedure used to calculate the mathematical results of the experiment. Each film-strip was 16-18 frames with audio tapes made by the teachers. Students spent between 8-15 minutes on this area of the review with many students repeating this area for added reinforcement.

(iv) Computer Drill & Practice Review:

**Purpose of Computer Review** - The computer review used a program called "Windows" designed to assist the students to accurately do the actual mathematical calculations from given experimental situations.
The computer responded to student requests for assistance by demonstrating graphic experiments of heat and expansion and prompting students at various stages of their performing the mathematical calculations. Students were confronted with four to five sets of experimental data and received a "print-out" of their responses. Most students spent 15 to 20 minutes on this portion of the review.

Paper & Pencil Review:

Purpose of Paper & Pencil Review - Paper and pencil review provided the student with experimental data to assist them in making the mathematical calculations required for the experiments.

The review question sheets provided the data. Students could make calculations on page 1. The paper was carbon-sensed and answers came through to the second page. Page 2 contained a complete solution with pictorial clues to focus on the specifics required to calculate the answers. The paper response was usually performed after the film-strip or computer drill and practice sessions.
Review Questions #1:
Calculate the **Rate of Expansion** of air from the following data:
1. Perimeter of Balloon Before Heating 7 cm = D1
2. Perimeter of Balloon After Heating 12 cm = D2
3. Time while heating 1 minute 40 seconds = T2
4. Time starting 0 = T1

Steps to follow
1. Change in Perimeter = Elapsed Time =
2. Rate of Expansion = \[
\frac{\text{Change in Perimeter}}{\text{Elapsed Time}}
\]

**INSTRUCTIONS**

On the above problem - write your answers opposite #1 and #2 using the same procedure outlined on the film-strips. After you have completed your calculations, lift up the sheet and review your answers. If corrections are required, correct the second sheet. When you have finished, proceed to page 3 and complete the final two problems.
Review Questions #1

Calculate the Rate of Expansion of Air from the following data:

1. Perimeter of Balloon Before Heating 7 cm = D1
2. Perimeter of Balloon After Heating 12 cm = D2
3. Time while heating 1 minute 40 seconds = T2
4. Time starting 0 = T1

Steps to follow

1. Change in Perimeter = Elapsed Time =
2. Rate of Expansion = Change in Perimeter = Elapsed Time
APPENDIX III
DESCRIPTION AND EXAMPLES
OF
INDEPENDENT STUDY RESOURCE MATERIALS

The individual review was designed to consolidate student knowledge on all aspects of the science experiments and related mathematics. The formative tests provided data to assist in determining the areas of weakness of each student and to direct him to review situations that would apply the appropriate educational correctives.

All review material provided visual, audio and drill and practice components. The reviews were designed to be situational to the specific classrooms and to be as focused as possible to assist the students participating in the study.

Description of Review Material:
(a) Video Presentation
   * Educational purpose ...

Each experiment was video taped with an auditory explanation focusing on "how to" conduct the experiment and what to observe. The experiment was done in the actual science laboratory and using identical equipment as that used by the students when they did the experiment. Video techniques, using close-ups and slow motion, were employed in order to focus on the critical experimental observations. Each video was four to five minutes in
length.

*Educational purpose ... this review provided a general overview of the experiment and assisted the student with his recall of his observations when he conducted the experiment.

(ii) **Slide Program:**

Purpose of slide program - to focus the student's concentration on the names of parts of scientific equipment, the organization of experimental set-up and the functional use of each piece of equipment. A series of slides was organized showing each part of equipment and the set-up of the experimental equipment. An audio tape was made to sequence with the slide presentation, which the student reviewed. The audio tapes were made by the two instructors and they focused their comments on the review of the scientific equipment and the experimental set-up.

A slide presentation could have between 20-30 slides and audio comment. The choice of whether a student received a long presentation or a short one was made as a result of the memory component from his formative tests.

The slide program usually required four to seven minutes for a student review.
(iii) **Film-strip Program:**

Purpose of Film-strip Review - each experiment had a film-strip, which outlined a review of the experimental set-up focusing on the measurements of time, temperature and length, which the students were to record. An audio review tape was sequenced to explain "how to" take the measurements and the "procedures" to record the observations.

The review program then proceeded to a step by step review with audio back-up of each step in the procedure used to calculate the mathematical results of the experiment.

Each film-strip was 26-28 frames with audio tapes made by the teachers. Students spent between 8-15 minutes on this area of the review with many students repeating this area for added reinforcement.

(iv) **Computer Drill & Practice Review:**

Purpose of Computer Review - The computer review used a program called "Windows" designed to assist the students to accurately do the actual mathematical calculations from given experimental situations.

The computer responded to student requests for
assistance by demonstrating graphic experiments of heat and expansion and prompting students at various stages of their performing the mathematical calculations. Students were confronted with four to five sets of experimental data and received a "print-out" of their responses. Most students spent 15 to 20 minutes on this portion of the review.

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The review question sheets provided the data. Students could make calculations on page 1. The paper was carbon-sensed and answers came through to the second page. Page 2 contained a complete solution with pictorial clues to focus on the specifics required to calculate the answers.

The paper response was usually performed after the film-strip or computer drill and practice sessions.
APPENDIX IV

TEST INSTRUMENTS USED FOR EVALUATION OF SAMPLE AND POPULATION

Test instruments used for evaluations:

(a) Pre-test conductivity of metals
(b) Post-test conductivity of metals
(c) Pre-test expansion of liquids
(d) Post-test expansion of liquids
(e) Pre-test expansion of gas
(f) Post-test expansion of gas
(g) Comprehensive evaluation after completion of experiment
A) Label the Parts on the Lines Below:
B) FILL IN THE BLANKS

Use the following terms to fill in the blanks.

- identical wax rings particles
- aluminum bunsen burner attractive forces
- brass hub test tube clamp spaces

1. The metal rods are all connected to the ________.
2. ________ has a dull yellowish colour.
3. ________ are placed at the ends of the metal rods.
4. The conductometer is held in position by the ________.
5. The heat is supplied by the ________.
6. The metal that melts fairly readily is ________.
7. All substances are composed of ________.
8. Molecules in substances are held together by ________.
9. Between the molecules in solids, liquids and gases are ________.
10. Particles of the same substance are ________.

C) TRUE - FALSE

1. ________ Aluminum has a grey metallic colour.
2. ________ The flame is placed directly under the hub.
3. ________ The timer clock only needs a minute hand for testing conductivity.
4. ________ Iron is a very common metal.
5. ________ Copper is an alloy.
6. ________ Alloys contain more than one element.
7. ________ The faster molecules vibrate the more they give off heat.
8. ________ According to the Particle Theory, the molecules are larger than the spaces between them.
9. ________ Molecules always vibrate at the same speed.
10. ________ Molecules of gases vibrate faster than molecules of liquids.
11. ________ All matter is made of molecules.
12. ________ Heat moving along metal is known as conduction.
13. ________ The temperature at which all molecule movement stops is at -273.15 °C, or Absolute Zero.
14. _______________ Iron is a faster conductor of heat than copper.
15. _______________ All the wax rings melt at the same time.

D) **CALCULATIONS**

1. The prongs of the conductometer are 10 cm long. After the Bunsen burner flame is placed in the hub of the conductometer, it takes 30 s for the wax to melt at the end of the copper prong. Calculate the rate of conduction of heat along in cm/s. (Use formula and calculator)

2. Calculate the rate of conduction of heat along the 10 cm brass prong if it takes 80 s for the wax to melt at its end. (Use formula and calculator)

Total: 41 marks

= ______ %
Expansion of Liquids

A) Label the parts on the lines below:

1. Thermometer
2. Pipette
3. Two-hole stopper
4. Test-tube stand
5. Flask
6. Wire gauze
7. Ring clamp
8. Bunsen burner
9. Bunsen burner stand
10. Gas flint lighter
B) **FILL IN THE BLANKS** Use the following terms to fill in the blanks.

- Can
- Expands
- Solids
- Pipette
- Celsius
- Convection
- Expansion gap
- Thermometer
- Gases
- Contracts

1. The **thermometer** is required to measure the temperature.

2. When the temperature is measured the answer is given in degrees °C.

3. The water rises up the glass tube called the **pipette**.

4. Molecules of liquids are closer together than molecules of __________.

5. The molecules in a liquid **can** move from place to place.

6. The movement of heat in liquids is called **convection**.

7. When liquids are heated the volume **expands**.

8. When liquids are cooled the volume **contracts**.

9. The space at the top of a bottle of "pop" between the liquid and the cap is called the **expansion gap**.

10. There is more expansion in liquids than in __________ for the same rise in temperature.

C) **TRUE - FALSE**

1. **F** Alcohol expands more than water for the same rise in temperature.

2. **F** Different liquids have different sized molecules so there is a difference in the amount of expansion.

3. **F** The spaces between particles in liquids are smaller than the spaces between particles in solids.

4. **T** Molecules in ice are more free to move than molecules in water.
5. When liquids are heated the volume contracts.
6. All matter expands and contracts the same amount.
7. When molecules vibrate slower they give off less heat.
8. Heat travels through liquids mainly by conduction.
9. In convection heat moves in all directions.
10. Liquids are known as fluids.
11. The temperature is recorded by the pipette.
12. Molecules of metals could be made to move from place to place by melting the metal.
13. Cold molecules are heavier than warm molecules of the same liquid.
14. When the movement of molecules speeds up, the temperature becomes higher.
15. Liquid nitrogen is used to study substances at cold temperatures.

D) CALCULATIONS

1. The temperature before heating is 20°C. The temperature after heating is 61°C. What is the change in temperature? (Show work)
   \[ (61°C - 20°C) = 41°C \]

2. The height of the water before heating is at the 6 cm mark. The height of the water after heating is at the 1 cm mark. What is the change in height? (Show work)
   \[ (6 cm - 1 cm) = 5 cm \]

3. If the 
   \[ \text{Amount of Expansion} = \frac{\text{Change in Height}}{\text{Change in Temperature}} \]
   Calculate the Amount of Expansion using the data from Questions #1 and #2 above
   \[ \text{Expasion} = \frac{5 cm}{41°C} \]

   Total \[ \frac{26}{40} \] = \[ \frac{65}{15} \]
A. Label the parts on the lines below:

1. ______________________
2. ______________________
3. ______________________
4. ______________________
5. ______________________
6. ______________________
7. ______________________
8. ______________________
9. ______________________
10. ______________________
B. FILL IN THE BLANKS - Use the following terms to fill in the blanks

can            pipette            expansion gap            gases
expands        Celsius            thermometer            convection            contracts

1. The _____________ is required to measure the temperature.
2. When the temperature is measured the answer is given in degrees _____________.
3. The water rises up the glass tube called the ________________.
4. Molecules of liquids are closer together than molecules of ________________.
5. The molecules in a liquid ________________ move from place to place.
6. The movement of heat in liquids is called ________________.
7. When liquids are heated the volume ________________.
8. When liquids are cooled the volume ________________.
9. The space at the top of a bottle of "pop" between the liquid and the cap is called the ________________.
10. There is more expansion in liquids than in ________________ for the same rise in temperature.

C. TRUE/FALSE

1. _____ Alcohol expands more than water for the same rise in temperature.
2. _____ Different liquids have different sized molecules so there is a difference in the amount of expansion.
3. _____ The spaces between particles in liquids are smaller than the spaces between particles in solids.
4. _____ Molecules in ice are more free to move than molecules in water.
5. _____ When liquids are heated the volume contracts.
6. _____ All matter expands and contracts the same amount.
7. _____ When molecules vibrate slower they give off less heat.
8. Heat travels through liquids mainly by conduction.
9. In convection, heat moves in all directions.
10. Liquids are known as fluids.
11. The temperature is recorded by the pipette.
12. Molecules of metals could be made to move from place to place by melting the metal.
13. Cold molecules are heavier than warm molecules of the same liquid.
14. When the movement of molecules speeds up, the temperature becomes higher.
15. Liquid nitrogen is used to study substances at cold temperatures.

D. CALCULATIONS

1 mark 1. The temperature before heating is 20°C. The temperature after heating is 41°C. What is the CHANGE IN TEMPERATURE? (show work)

1 mark 2. The height of the water before heating is at the 6 cm mark. The height of the water after heating is at the 1 cm mark. What is the CHANGE IN HEIGHT? (show work)

3 marks 3. If the

\[ \text{Amount of Expansion} = \frac{\text{Change in Height}}{\text{Change in Temperature}} \]

Calculate the amount of expansion using the data from questions #1 and #2 above. (use calculator. show mark)

TOTAL) \[ \frac{40 \text{ marks}}{} \]

\( ) = \boxed{\_\_\_\_\%} \)
A) Label the parts to the right of the numbers.

- Retort Pole
- Balloon
- Cloth Measuring Tape
- Glass tube
- One Holed Rubber Stopper
- Test Tube clamp
- Erlenmeyer Flask
- Boiling chips
- Wire Gauze
- Ring Clamp
- Bunsen Burner

- Retort case
- Flint lighter
b) **Fill in the Blanks**. Use the following terms to fill in the blanks.

- Volume
- Condensation
- Convection
- Expand
- Mixture
- Evaporation
- Boiling chips

1. Air is a _mixture_ of gases.
2. Gases _expand_ with heat.
4. The method of heat movement in gases is called _Convection_.
5. In gases the direction of heat movement is _Horizontal_.
6. On the inside of the balloon water droplets formed. These droplets are called _Condensation_.
7. Gases and liquids are capable of being "poured". Therefore, they are said to be _fluids_.
8. The amount of space or capacity inside the balloon is called its _Volume_.
9. A measuring tape was used to measure the distance around the outside of the balloon. This distance was called the _Perimeter_.
10. To prevent overheating of the glass at the bottom of the graduated flask we placed _boiling chips_ at the bottom on the inside.

C) **True-False**

1. T Gases expand less with heat than liquids for the same degree of temperature rise.
2. F In convection, heat moves in all directions.
3. T The particles making up gases are closer together than in liquids.
4. **F** The molecules in gases are always vibrating.

5. **F** The ring clamp supports the bunsen burner.

6. **T** A one-holed stopper was used for the "expansion of gases" experiment.

7. **T** Cold air is lighter in weight than warm air of the same volume.

8. **F** "Hot air balloons" make use of the idea of conduction of heat.

9. **F** In the convection "smoke" box, the air in the chimney above the burning candle flame was expanding and rising.

10. **F** Adding heat to a gas lowers the temperature.

11. **T** When the temperature drops, the speed of the molecules gets faster.

12. **T** Molecules can move from place to place in all three states of matter.

13. **F** Heat moves from a cooler place to a warmer place.

14. **T** The greatest percentage of room air is taken up with nitrogen gas.

15. **T** The Rate of Expansion = \( \frac{\text{Change in Perimeter}}{\text{Time}} \) for the balloon experiment.

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**D) CALCULATIONS**

1. If the perimeter before heating is 12 cm and the perimeter is 23 cm after heating, what is the change in perimeter? (Show work)

   \[ 23 \text{ cm} - 12 \text{ cm} = 11 \text{ cm} \]

2. If the balloon perimeter increases by 13 cm and the elapsed time of heating is 135 s, calculate the rate of expansion. (Use calculator and show work)

   \[ \frac{13 \text{ cm}}{135 \text{ s}} = \frac{13}{135} \text{ cm/s} \]

   **0.09 cm/s**
3. If the balloon perimeter increases by 14 cm and the elapsed time is 2 min and 42 s calculate the rate of expansion of the gas in the balloon after the heating. (Use calculator and show work.)

\[ 14 \text{ cm} = 2 \text{ s} + 4 \text{ cm} = \frac{545}{12} \]

Total \[ \frac{19}{50} \]

= \[ \frac{38}{100} \]

Memory \[ \frac{11}{13} \]

Comprehension \[ \frac{6}{25} \]

Calculations \[ \frac{2}{12} \]
EXPANSION OF GASES

A) Label the Parts to the Right of the Numbers:

1. 
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100. 

Teacher:
B) FILL IN THE BLANKS  Use the following terms to fill in the blanks:

- fluids
- volume
- upward
- convection
- expand
- mixture
- perimeter
- condensation
- contract
- boiling chips

1. Air is a ____________ of gases.
2. Gases ____________ with heat.
3. Gases ____________ when cooled.
4. The method of heat movement in gases is called ____________.
5. In gases the direction of heat movement is ____________.
6. On the inside of the balloon water droplets formed. These droplets are called ____________.
7. Gases and liquids are capable of being "poured". Therefore, they are said to be ____________.
8. The amount of space or capacity inside the balloon is called its ____________.
9. A measuring tape was used to measure the distance around the outside of the balloon. This distance was called the ____________.
10. To prevent overheating of the glass at the bottom of the erlenmeyer flask we placed ____________ at the bottom on the inside.

C) TRUE - FALSE

1. _____ Gases expand less with heat than liquids for the same degree of temperature rise.
2. _____ In convection, heat moves in all directions.
3. _____ The particles making up gases are closer together than in liquids.
4. _____ The molecules in gases are always vibrating.
5. _____ The ring clamp supports the bunsen burner.
6. _____ A one-holed stopper was used for the "expansion of gases" experiment.
7. _____ "Hot air balloons" make use of the idea of conduction of heat.
8. _____ Cold air is lighter in weight than warm air of the same volume.
9. In the convection "smoke" box, the air in the chimney above the burning candle flame was expanding and rising.

10. Adding heat to a gas lowers the temperature.

11. When the temperature drops the speed of the molecules gets faster.

12. Molecules can move from place to place in all three states of matter.

13. Heat moves from a cooler place to a warmer place.

14. The greatest percentage of room air is taken up with nitrogen gas.

15. The Rate of Expansion = \( \frac{\text{Change in Perimeter}}{\text{Time}} \) for the balloon experiment.

D) CALCULATIONS

1. If the perimeter before heating is 12 cm, and the perimeter is 22 cm after heating, what is the change in perimeter? (Show work.)

2. If the balloon perimeter increases by 12 cm and the elapsed time of heating is 135 s, calculate the rate of expansion. (Use calculator and show work. Use formula)

3. If the balloon perimeter increases by 14 cm, and the elapsed time is 2 min. and 42 s, calculate the rate of expansion of the gas in the balloon after the heating. (use calculator and show work. Use formula)

TOTAL: 50

Memory = \( \frac{13}{25} \)

Comprehension = \( \frac{25}{25} \)

Calculations = \( \frac{12}{12} \)
Expanions of Gases

Label the parts of the drawing.
Label the drawing.

Answer the questions below.

1. What part of the conductometer are the five rods attached to?

2. Why are "boiling chips" placed in the bottom of the Erlenmeyer flask?

3. Why is a wire gauze used under the Erlenmeyer flask?

4. What colour should the flame be?

5. Why are wax rings placed at the end of the metal rods?
CALCULATIONS:

1. The temperature before heating is 27°C. The temperature after heating is 45°C. What is the change in temperature? (Show your work).

2. If the perimeter before heating is 7 cm. and the perimeter is 21 cm. after heating, what is the change in perimeter? (Show your work).

3. If the balloon perimeter increases by 20 cm. and the elapsed time is 2 minutes and 21 seconds, calculate the rate of expansion of the gas after heating. (Use formula and show your work)

4. Calculate the rate of conductivity from the following data:
   (a) Length of metal = 70 cm.
   (b) Time after heating = 2 min. 10 seconds
   \[ R_c = \frac{L}{T} \]
5. Calculate the length of rod:

\[ R_c = 0.8 \text{ cm/s}. \]

\[ T = 1 \text{ min. 10 s}. \]

6. Calculate the amount of expansion:

\[
\text{Amount of expansion} = \frac{\text{Change in Height}}{\text{Change in Temperature}}
\]

Temperature before heating = 27°C
Temperature after heating = 45°C
Height of water before heating = 4 cm.
Height of water after heating = 1 cm.
True or False

1. ______  Gases expand more with heat than liquids for the same degree of temperature rise.

2. ______  In conduction heat moves in all directions.

3. ______  The molecules in air only vibrate when heated.

4. ______  Adding heat to gases causes the molecules to vibrate more rapidly.

5. ______  The Rate of Expansion = \frac{\text{Change in Perimeter}}{\text{Time}}

   for the balloon experiment.

6. ______  Molecules in gases move faster as the heat is removed.

7. ______  Cold air is lighter in weight than warm air of the same volume.

8. ______  For the same rise in temperature, alcohol expands more than water.

9. ______  The expansion of a liquid is called conduction.

10. ______  When molecules vibrate faster the temperature rises.

11. ______  The thermometer measures the temperature of the liquid in the beaker.

12. ______  Liquids are known as fluids.

13. ______  A one-hole stopper is required for the experiment on expansion of liquids.

14. ______  All liquids have heat move due to conductivity.

15. ______  Alloys contain more than one element.

16. ______  Iron is a faster conductor than aluminum.

17. ______  All the wax rings melt at the same time.

18. ______  Heat moving along the metal rods is known as conduction.

19. ______  The flame is placed directly under the hub.

20. ______  Aluminum has a rapid rate of conductivity.
Fill in the blanks - terms above:

(a) Fill in what the term or name is for each part of the formula:

\[ R_c = \frac{L}{T} = \frac{R_c \text{ stands for }}{L \text{ stands for }} \frac{T \text{ stands for }}{\ldots} \]

(b) The ________________ are all connected to the hub.

(c) The bunsen burner is always lit with the ________________.

(d) The water rises up the glass tube called a ________________.

(e) There is more expansion in ________________ than in solids for the same rise in temperature.

(f) The ________________ is required to measure temperature.

(g) The ________________ are in the bottom of the flask to prevent the heat from shattering the glass.

(h) The ________________ is used to support the Erlenmeyer flask.

(i) Air is a ________________ of gases.

(j) The method that heat moves in gases is called ________________.

(k) We measure the change in ________________ of the balloon during the experiment.

(l) Gases ________________ when cooled.

(m) Gases are less dense than ________________.