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THE RELATION BETWEEN INTELLIGENCE AND ACHIEVEMENT USING COMPUTER-ASSISTED INSTRUCTION

by

(C) KENNETH GORDON BROWN

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

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The undersigned certify that they have read and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "The Relation Between Intelligence and Achievement Using Computer-Assisted Instruction," submitted by Kenneth Gordon Brown in partial fulfilment of the requirements for the degree of Doctor of Philosophy.

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ABSTRACT

In general, prediction of future school achievement is based on intelligence tests administered to students early in their school careers. The present study centres around the questions:

> What is the relationship between achievement and intelligence when students are taught subject-matter by a computer? Are the abilities as measured by intelligence tests, required under the classroom learning situation the same as under computerized instruction?

The theoretical part of the investigation was a review of the literature discussing the difficulaties of measuring intelligence and questioning whether ability to learn is related to intelligence measures. Advantages and disadvantages of using a computer as an instructional device also were presented as well as criticisms of the existing classroom situation from a learning standpoint.

The emperical study involved two schools as a population from which experimental and control groups were randomly selected. The twenty-four experimental students received instruction for about one month from a computer while the control students received the same material in the classroom. Hypotheses were tested using both biased and culture-reduced intelligence measures as well as achievement in science by a pretest, a posttest and a two-week later posttest. Attitudes towards the subject were also measured by pre- and post-attitude tests.

It was found that there were no differences in achievement between the experimental and classroom groups except for low ability students, favouring the classroom group. The computer-taught group however had less than 60% of the time available to the classroom group for instruction. The male attitudes towards the subject did not change under either instruction condition, but the attitude towards the subject of the girls in the classroom group decreased. This was not the case for the girls taught by the computer.

Correlations of achievement and intelligence for both groups were no different but trends supported higher correlations for the classroom group with the biased intelligence test scores. This trend was reversed however for the girls of the computer group which had a higher correlation with the culture-reduced intelligence test.

In general, the computer group did learn faster. The relationship between intelligence and achievement appears to be a function of the bias of an intelligence test and the degree to which instruction is individualized.

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K. G. B.

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CHAPTER 1

INTRODUCTION

For a number of years, intelligence test scores or IQ have been observed to correlate significantly with school achievement. On this basis, the IQ has been used to predict future achievement and it is assumed to be related to ability to learn. Thus intelligence tests are administered in the schools and students may then be streamed into rapid, average or slow groups for instructional purposes.

Woodrow (1946) in analysing gain scores for school achievement and psychological tests, disputed the assumption that ability to learn is related to IQ. He suggested that ability to improve with practice is confused with ability to learn.

Correlations of intelligence and achievement have seldom exceeded .70. Thus one-half of the variance is influenced by other factors not related to intelligence.

Eells (1951) reported that intelligence tests appear to discriminate against low socio-economic children. They were able to improve their scores however, when provided with a richer environment. Elley (1961) investigated intelligence tests to establish the degree of socio-economic bias. Those tests which had the highest bias were the best predictors of school achievement, while those with the least bias were the poorest predictors. This raises the question whether the tests measure learned performance in addition to some more basic ability they purport to measure. West (1962) suggested that IQ tests have tended to include more performance items to enable better predictive power. Thus the test becomes a type of achievement test which would be expected to correlate with school achievement more highly.

Another problem arises if the IQ tests have socio-economic bias. Rosenthal (1966) has found that teacher expectations can influence student achievement. If a teacher bases his expectations on the results of a biased intelligence test, he can influence perhaps in a negative way, the child's achievement in school.

There is evidence to show that programmed instruction (PI) reduces differences in achievement among students of varying intelligence (Ferster and Sapon (1958), Porter (1959) and Carr (1960)). This suggests that intelligence may have less influence on achievement with PI. The impersonality of the program may tend to overcome the problem of teacher expectations having a deleterious effect.

However, the use of PI in the schools has not been extensive. Silverman (1964) claimed that the word 'machine' raises antagonism in teachers, suggesting dehumanization and thought control. Teachers fear that machines are competing for their jobs. Stolurow (1964) suggested that educators feel that there is a fundamental need for a variety of experience involving social interaction not provided by machines. The claims made for PI have not been lived up to by research, argued Pressey (1964). PI has not shown conclusive proof of any superiority over conventional classroom instruction. Teaching machines have proven difficult to maintain and hence have been avoided by female teachers particularly. Programs have not been readily available for all subject areas and additional costs to an already strained education budget have not been justifiable from an administrator's viewpoint. Pressey (1960) argued that teachers want convenience, not a bother and PI may be just too much trouble.

Would the use of a computer as an individual tutor overcome some objections to teaching machines? Being more sensitive to the responses of the learner, the program tends to guarantee learning. Experience shows that machines have not substituted for rational thought in business and industry. Fears of job competition have not deterred industry from using computers. People are retrained for new roles to complement computer use. The same can apply to teachers who actually would have more control over the teaching computer than business employees. Who is in a better position to produce and update programs which the computer will use than teachers? The maintenance of the computer would not be a teacher responsibility and program revisions can be made on the memory disk which is instantly available to all students. Though costs are initially higher than those of PI, the system flexibility will mean an approach to the ideal personal tutor. Licklider (1962) predicted costs for computer-assisted instruction (CAI) to be less than one dollar per student-hour within five or six years. Zinn(1966) quoted eventual costs of fifty cents per student-hour for secondary students, and twenty-five cents for primary school students.

It is the principal purpose of this project to examine the achievement of a group of students taught by a computer and more specifically to study the relationship between achievement and intelligence measures when the latter are obtained by standardized intelligence tests.

CHAPTER II

RELATED RESEARCH AND THEORY

Ability and Achievement

Carr (1960) stated that effective instructional devices may erase differences in achievement measures associated with intelligence test performances. Ferster and Sapon (1958) found very low correlations between aptitude and achievement in a German course with college students and adults using PI texts. Porter (1959), with elementary school children, found the correlation between IQ and achievement in spelling not significantly different from zero for students taught by a teaching machine. There was however a significant positive correlation for children taught in a conventional classroom.

One suggestion for the decrease in correlation is that the programmed instruction produces more homogeneity of achievement scores. If a student can repeat a portion of a course until he feels that he understands it, there is likely to be more thorough learning. Homme and Glaser (1959) and Evans, Homme and Glaser (1960) found that students using PI had higher and less variable achievement scores than those students receiving conventional instruction in the classroom.

Stolurow (1960a) and Blackman and Holden (1963) used programmed instruction with retarded children. Stolurow stated,

> "It would appear that with efficient methods of learning, the poorer student is assisted

> sufficiently so that he becomes, in terms of criterion performance, undistinguishable from the more able student" (P438).

Both he and Blackman claimed that the adaptive teaching machine (such as a computer) can be made to adjust to the individual's needs to more or less guarantee mastery. The machine is potentially as sensitive to errors as the most sensitive teacher. It never gets angry or exasperated and may have novel appeal prompting motivation. The impersonal learning situation and immediate feedback may be less likely to arouse anxieties associated with past student-teacher relations.

Ability and Learning

Woodrow (1938) investigated practice and its effects on performance. By factor analysis he found changes in the factor loadings as a result of practice. There was no significant change in the correlation of the the first factor (intelligence) with the intelligence tests administered before and after practice. He concluded that there was no tendency for the amount possessed of an initially important ability to have any bearing upon the change with practice. He stated,

> "Even the possession to a high degree of an ability--------- does not necessarily result in a high gain score" (P229).

In a later study, Woodrow (1945) decried the assumption that the ability to improve has been believed to be synonymous with intelligence. Standardized achievement tests in six school subjects were factor analysed to seek out a common factor, intelligence or otherwise, manifested in the gains of various school subjects. No gain factor was found for a given course within any grade which had to do with gain in all six subject matters. He concluded,

> "If the first measurements of intelligence and achievement are made beyond the fifth grade, the indications are that intelligence --------- is a rather minor factor in accounting for individual differences in improvement in any specified number of additional years" (P165).

However, since these results are based on gain scores, they must be questioned. Woodrow in neither study gave any information about the reliability of the gain scores. Gulliksen (1950) stated,

> "Unless the average reliability of two tests is considerably higher than the correlation between them, the differences will be very unreliable. Unless the reliability of the differences is .80 or larger, valid judgments cannot be made on the basis of score differences" (P359).

With no mention of the reliability of the gain scores, the question is an open one whether gain scores with sufficient reliability were used. Thus any conclusions based on gain scores must be viewed with some suspicion.

Statements identifying learning ability with intelligence are so frequent that Woodrow (1946) suggested that one may form an opinion that such identification is beyond dispute. The implied argument is that how well a student performs on an intellignece test measures how well he can learn. Woodrow believed that achievement is confused with the ability to gain with practice. Although intelligence test scores correlate significantly with test scores, Woodrow reported that in 120 investigations, the average correlation was 0.56. If the true correlation is assumed to be as high as .707, and it is further assumed that intelligence is the basis of achievement, then only fifty percent of the variance is accounted for. Thus factors which are uncorrelated with intelligence have as much to do with determining achievement as has intelligence. Certain motor skills show no correlation with intelligence yet show marked improvement with practice. Woodrow (1946) further supported his conclusions with evidence of several studies using psychological tests and standardized school achievement scores. Again he concluded there is no gain factor and no correlation between gain scores and IQ beyond grade five. However, again with no gain score reliabilities mentioned, his conclusions are open to question.

The performance of a child on an intelligence test is a function of two factors: his innate ability and his experiences. Elley (1961) analysed several intelligence tests to determine the extent to which they were biased against different socio-economic levels. He regarded intelligence statistically as a hierarchical construct characterized by a broad general factor 'g' and narrower ability or environmental factors. By factor analysis of intelligence test scores, different loadings for the general and specific factors provided evidence for a bias level for each test. These results supported Hebb's (1949) concepts of intelligence A, the innate potential, and intelligence B, the present performance level which is a function of experience. Vernon (1961) recognized that different intelligence tests will assign different values to B, so he added intelligence C as an estimate of B made from an intelligence test.

West (1962) concluded that intelligence tests attempt to measure intelligence B, but there are many kinds of tasks exhibiting intellectual abilities. They can only sample differentially among these abilities, so different tests yield different estimates of intelligence B.

Elley (1961) believed that in order to improve prediction of school achievement, tests purporting to measure intelligent behaviour have become more like measures of achievement and experiences. This trend would therefore result in a bias against different socio-economic groups and show a closer relationship of intelligence and achievement scores. Thus the significant correlation of intelligence and achievement scores may result because both are achievement tests to varying degrees.

The problem of estimating intelligence A is therefore confounded by achievement, which is a function of the environment. The lay concept of intelligence tests measuring only intelligence A is wishful thinking and is not supported by research. Some tests are however better estimates of A than are others as shown by Elley (1961).

The evidence on the relationship between intelligence scores and school learning is not clear. If a test measures intelligence A and B in some combination, then the measures of school achievement are influenced by the environment. One cannot conclude that because intelligence scores correlate with achievement scores, therefore intelligence A also correlates with achievement, since the measure of intelligence is confounded with the effects of experience.

The evidence appears to support Carroll's model of school learning (1963) because only one of his five elements is intelligence. Stolurow (1960b) believed that if Woodrow is supported in claiming that intelligence is not related to learning ability, then a school learning task requires a minimum ability level and the rate at which learning occurs is a function of other factors. He further suggested that research should be directed at those variables which determine the rate of learning.

Related Research on Programmed Instruction

Carr (1960) defined three classes of variables of which the effectiveness of a self-instructional device is a function:

1) the characteristics of the device
2) the characteristics of the program
3) the characteristics of the learner

Characteristics of the Device

Programmed texts and 'crank-type' machines which present the question and answers in sequence are the simplest devices. These present information, ask for a response, and the answer is then supplied. The machines can provide for a written answer before the correct answer is provided or allow a choice of answers. Then the next frame is not allowed to be presented until the correct answer is selected. The machine can thus demand an answer before showing the correct one and at the same time record the student's response for the teacher's use. Cummings and Goldstein (1964) found that overt responses are necessary for long and difficult material, but are not required for short and simple tasks. Thus the programmed text appears to be more suitable for short and simple learning tasks. Although overt responses can be requested, only a machine can guarantee and record it. Hence they are more suitable for difficult tasks.

The computer has more flexibility in presenting information using multiple input senses of the individual. TV and film screens can make use of pictorial scenes as well as textual material. The audio input can clarify or add realism to a situation. Responses of the pupil can be verbal using the voice for later analysis by a teacher, or written using the typewriter keyboard. Light pen responses enable rapid non-verbal input allowing very young children to use the system.

The memory storage of the computer allows many answers to be stored, be they right or wrong, allowing more sophisticated feedback to the student on the adequacy of his responses. Analysis of the response enables more effective use of help sequences or cues to assist the direction of the student's learning and finally to confirm his response.

Characteristics of the Program

Branching (Crowder, 1964) and linear (Skinner, 1958) type programs have both been used with texts and teaching machines. Coulson and Silberman (1960) and Silberman et al (1964) found no differences in achievement with branching or linear programs, but branching required less time.

Although Skinnerian programs are designed and then tested to reduce the possibility of errors, thus eliminating the learning of incorrect responses, Crowder (1964) questioned why all students regardless of their differences should be required to follow the same path? The linear program must fit the most poorly prepared student and never give more information or require more reasoning than that of the slowest pupil. Surely this wastes the time and bores the average or bright pupil and is based on pessimistic assumptions about the student.

The computer can consider many criteria for branching other than a wrong answer. Bushnell (1962) suggested that the response, the history of the student's learning behaviour, relevant personal data, the degree of student motivation, the nature of the subject matter, and finally student requests, as branching criteria. In this way unique branching is possible to fit the individual's needs. Stolurow (1964) would have the computer tailor the program to the individual's ability profile stored in its memory. Thus the rapid branching and storage capabilities of the computer suggest a means to approach the unique learning style of each student.

Fry (1960) investigated whether the multiple choice mode of responding promotes more effective learning than the constructed answer type of program. He concluded that if recall of information is the criterion, the constructed answer is superior, but required more training time than multiple choice. If recognition is the criterion for learning, then multiple choice may be the more effective technique.

How large should the learning steps of a program be? Evans et al (1960) found with linear programming that smaller steps produced better immediate test performance, retention, and fewer errors of response. Wilton (1966) however found no support for the size of step affecting learning or retention for mental retardates. This problem appears to be of little importance for branching programs, but it would influence the remedial branches that a student meets. He must be taught by linear small step programs at some stage of branching since there is a limit to the number of branches that an author will allow a student. Coulson and Silberman (1960) found the small step program required more time to complete, but also produced higher achievement scores compared to large step programs. No mention was made of the ability of the students in the study nor their background knowledge. It may be that the more knowledgeable a student is about a topic, the larger the step size can be compared to the step size for another student who has no background in the topic. A computer program however can be made to recognize the individuality of the learner and structure the step size to suit his ability profile. The more heterogeneous are the students, the more variation is likely to be required in step size. Until more is known about factors which influence step size, the computer cannot be fully utilized to suit the size of the steps to the individual.

Should the program prompt the student and cue him towards a goal, or simply confirm whether his response is right or not? Stolurow and Lippert (1964) with sight vocabulary, and Cook and Spitzer (1960) with paired-associate material, both found faster learning from prompting, but better retention from confirming techniques. Although confirmation is slower because the correct response is less probable, once the association has been established, it achieves higher levels of integration and therefore is retained longer. The prompting technique interferes with the association's integration level keeping it low. Thus the learned association is not retained.

<u>The Characteristics of the learner</u>

Each student is an individual with different abilities, attitudes, values and motivational levels. Skinner (1968) criticized the aversive nature of the existing school which has replaced the birch rod with criticism, ridicule and failure threats. He argued that aversive threats only contribute to truancy, drop-outs, vandalism and from the learning point of view, mental fatigue, forgetting and apathy. Sarason (1961) with his U-shaped function relating anxiety level and achievement presents evidence that very high or very low anxiety levels result in low achievement. If an aversive control situation promotes high anxiety, then achievement may suffer. Those students who are in trouble with the teacher or administration are probably anxious because of the aversive punishments they must accept. Hence their treatment tends to discourage learning rather than encouraging it. Once student-teacher conflicts arise, both may become easily aroused to a high anxiety level and the student's achievement declines.

There is the impersonality of the computer along with its Hawthorne effect which should help reduce anxieties due to former pupil-teacher interactions and perhaps promote motivation to learn. Grubb and Selfridge (1963) found that computer-taught statistics to a college class reduced the instruction time by 90 percent and the average achievement score was 94.3 compared with 58.4 for a lecture-taught class. These results suggest support for superior learning in a shorter time. There was no mention however of the controls along with reliability or validity of the test instruments, so these results are tentative and subject to cross-validation studies.

Attitudes of pupils towards a subject depend largely on former experiences with it and associated teachers. If a student who has been having difficulty with a subject receives a new teacher who can assist him to reach a high degree of achievement, will this change his attitude towards the subject to a more favourable one? If however the new teacher uses anxiety creating and/or aversive control techniques, an increase in achievement may result, but whether there will be a more favourable attitude change is questionable. It may even become less favourable because antagonism towards the teacher may be transferred to the subject.

Thus an increase in achievement may or may not produce more favourable attitudes towards a subject, depending on how the achievement is brought about. Finally, the value the student places on the increase in achievement will influence any attitude changes. If his perceived value is low, there is unlikely to be any changes in attitude as a result of higher achievement.

Reinforcement

Skinner (1968) believes knowledge of the correct answer is all the student requires to encourage him to learn. He must be reinforced immediately and frequently however to shape his behaviour along desired lines. Moore and Smith (1964) observed that spelling behaviour was not influenced by the immediacy of reinforcement. However in the discussion, the authors mention that the answers were used in sentences in later frames. Since each student had twenty minutes for the task, he could be reinforced within a minute or two depending on how soon a previous answer was used in a following question. Thus the time for reinforcement was a variable and the conclusions reached are on rather shaky ground since no fixed time control was made on the length of time before an answer was made known to the student. Although not instantaneous, the matter of a few minutes delay may not have any adverse effects on learning since no significant differences were found between the group given immediate reinforcement and the group not given immediate reinforcement.

Annet (1964) believes that reinforcement has been interpreted as: 1) a technique and 2) the consequences of the technique. The term should not be used as a substitute for other related terms such as knowledge of responses. Greenwald (1964a) claimed that information about the accuracy of performance is the essential ingredient of reinforcement, rather than the reward. His law of information defines achievement as a function of the amount of informational feedback and the number of trials. The effectiveness of rewards as motivators depends on the value the student places on the reward, his value of the process to achieve it, and his confidence in the probability of attaining the reward.

Therefore, reinforcement as applied to programmed instruction may have two functions:

1) feedback about the adequacy of responses and
2) a motivational function depending on the individual's evaluation of the rewards resulting from success of the learning task.

<u>Some Teacher Effects</u>

Finn (1964) looks at teaching machines as a technological solution to the problem of individual differences since no teacher can tutor each student but machines can for certain subject matter and portions of a school day. The use of machines will demand more of the teacher in terms of education, experience and professional growth. He must have more understanding of learning theory and sound judgment to determine what goals can best be achieved by programmed instruction and other means.

There is evidence to support the effect of a teacher's expectations on pupil achievement. Rosenthal (1966) discussed experimental effects of the teacher and concluded that a child's whole school progress can be altered by his reputation which precludes him through the school. If this reputation is based on the results of an intelligence test which is highly biased against the socio-economic status of the child, he probably will not achieve near his potential, which may be high but is not measured by the test.

Rosenthal and Jacobson (1968) found significant increases in the IQ of disadvantaged children as a result of Federal Government-financed remedial and cultural enrichment programs. These increases were not as great however as those measured in a school system where only the teacher's expectations of a random sample of students were raised at far less cost and effort. This suggests that teacher's attitudes towards students are somehow communicated to them and influence their achievement.

Silverman (1964) discussed program methodology. A program forces a teacher to analyze in great detail what he is trying to teach. Critics may consider this to be beneath their dignity and argue that it is training, not education.

If learning is to be based on the individual ability profile, Stolurow (1964a) predicted changes in school organization and laws because achievement now proceeds in association with calendar dates, not intellectual growth. His paper (1964b) pointed out the problem of getting teachers to accept and use PI. Special and regular courses are needed to train the teacher how to use it.

Skinner (1968) concluded,

> "A technology of teaching improves the role of the teacher as a human being. It provides capital equipment which gives him some of the time he needs to be human. It frees him from the need to maintain aversive control or motivate his students in spurious ways. It gives him time to take an interest in his students and advise and cousel them" (P257).

Some Criticisms of Computer-Assisted Instruction (CAI)

Riedesal and Sugdam (1967) warned of the time required to program a course. Two man years of effort produced two college semester courses. Estimates are that from 60 to 100 hours are required of an author's time are required for one hour of student instruction. This naturally increases program costs, but if used by thousands of pupils, initial costs are misleading. Gerard (1967) questioned whether costs will ever be competitive with conventional methods. Costs however, must be evaluated with respect to the end product, namely the student who learns.

Goodlad et al (1966) asked how the teacher's role will be changed? They also questioned whether the computer will be psychologically threatening to the student? Skinner would probably suggest that it cannot be worse than the aversive situation in which the students now find themselves under the present situation.

Hilgard (1964) has worried about the sedentary nature and lack of social participation by the student. How does the student learn to participate with others in solving problems or learn civic responsibility? Porter (1957) complained that critics cannot conceive that complex human endeavours can be analysed into precise units suitable for mechanical presentation. Although some subject materials seem to be more suited to CAI than others, there is no proof that the traditional teaching system is the best for the many subjects taught in the schools.

Gentile (1965) argued that there is no theory of CAI from which learning principles can be deduced appropriate to the situation. He criticized the lack of replication studies and questioned the value of individual difference measures unless they are predictive of educational performance. Finally and most crucial, adaptation to individual differences must prove itself superior to teaching aimed at the mean of the group. Cronbach (Gentile, 1965, P26) argued that different treatments for groups depend on the validity of the placement test. If validity is zero, the maximum utility is obtained by teaching to the average of the population. As validity increases, treatments may vary more, but no matter how valid the test, there is an optimum degree of differentiation of treatment. Sectioning beyond this degree can result in a loss of utility even though the placement test has considerable validity for sectioning.

This optimum under normal classroom and CAI could be quite different. Thus marked alteration of treatment to fit the individual is advisable only when differences are validly assessed and their implications for treatment are clear. Until parametric studies of individual treatments are done which support improved learning, a good program for the average of the population is the most effective, which is what a teacher tries to provide.

This psychometric problem of selection and costs for different treatments is not quite applicable to CAI. There is no selection problem because each student will receive his own individual program. The costs of the treatment however must be evaluated in the light of the results obtained by teaching each individually. One of the hypotheses of this study is to determine whether or not there is significantly better achievement using CAI for individual tutoring.

Summary

Evidence relating IQ and achievement has been a basis for predicting future learning ability. The question arises however whether achievement is confused with the ability to gain with practice.

Factor analysis of gain scores failed to produce any common factor, intelligence or otherwise, manifested in various school subjects. Neither practice effects nor gain scores have correlated significantly with intelligence test scores suggesting that intelligence is a minor factor in accounting for improvement.

Correlations of intelligence with achievement range from 0.5 to 0.6. If the correlation was as high as .707, only fifty percent of the variance would be accounted for and other factors would have as much to do with determining achievement as do current measures of intelligence.

Elley (1961) has shown that intelligence tests are performance biased to different degrees. The greater is this bias, the better predictor a test is for future school performance. However, if the test measures learned performance (intelligence B) along with innate ability (intelligence A), then the relationship of intelligence scores and achievement may be a result of mainly intelligence B while intelligence A bears no significant relation to achievement. If both intelligence A and B are confounded in the IQ score, then one cannot conclude that the relationship with achievement is a result only of innate ability or intelligence A.

There is also evidence to suggest that programmed instruction may erase differences in achievement on the basis of IQ. This supports the concept that factors other than innate ability can influence achievement. The main reason offered is the flexibility of the machine-student interaction. The more sensitive the machine is to the student responses, the more likely he can be taught to a criterion level. The computer being flexible and fast enough to meet the needs of a large number of students, should approach the criterion of an ideal teaching machine. With many student stations, the cost can become reasonable in the light of the results with the individual.

Neither branching nor linear-type programs result in superior learning, but the former requires less time. The computer program has the potential to consider many criteria other than the student's immediate response as a basis for branching. The multiple-choice mode of responding promotes better recognition of information than constructed answers. The latter however results in better recall of information at the expense of more learning time. Step size, when small requires longer time but results in fewer errors and higher achievement scores. Prompting programs result in faster forgetting than confirmation types but promote faster learning also.

The effectiveness of reinforcement depends on feedback about the adequacy of the responses and the value the student places on the reward for success. Attitudes, abilities and motivation vary with pupils and poor teacher-student interactions may raise the anxiety level too high for optimum achievement. It is to be hoped that the impersonality and non-aversive interaction with a computer will promote motivation to learn.

Teaching machines will demand more training, experience and professional growth from teachers. They must be given opportunities to attend courses on their usage and program development. Skinner (1968) concludes that machines will give the teacher time to be human, to take an interest in, and advise and counsel his students.

Criticisms of CAI range from fears of excessive cost to the psychological threat of the machine. Replication studies are lacking and the value of individual adaptation must prove itself to be superior to teaching aimed at the mean of the group.

CHAPTER III

THE PROBLEM AND ITS SIGNIFICANCE

Achievement and Intelligence Measures

Generally the intelligence measure or IQ has been used to predict achievement in the classroom. If instruction is individualized with the computer, Stolurow (1960a) suggested that the program may enable a more efficient method of learning, so all children will achieve to the same criterion regardless of ability.

If the correlation of achievment and IQ is low, there can be little prediction based on IQ. If however the correlation of achievement and IQ is high, then prediction is more accurate with fewer other factors to influence achievement. Correlations of .4 to .5 are not particularly high, although they do indicate an important relationship.

With CAI, a high correlation between achievement and IQ tests enables prediction of achievement as in the classroom. If the correlation between achievement and IQ is low under CAI conditions, then the components of achievement do not relate to IQ as much as in the classroom. This raises the question: How important is IQ as a predictor of achievement under CAI conditions? Can any student with an educable IQ level attain a given criterion level of achievment under CAI conditions?

Most testing for achievement in schools occurs weeks or months after instruction. Perhaps the relation of IQ and achievement results from differential rates of forgetting rather than ability to learn. In the context of CAI then, it may be possible by adequate individualization of the program to bring students of widely different abilities to the same level of achievement producing a low correlation between IQ and achievement. With passing time, a higher correlation between IQ and achievement may result because of differential forgetting being a function of IQ. This implies specific review programs to reduce forgetting to a minimum after the criterion level has been established.

Measurements of intelligence by IQ tests are either biased or culture-reduced as reported by Elley (1961). The relationship of these tests to achievement may vary depending on the teaching conditions.

a. Under Classroom Conditions

The group situation in the classroom requires good verbal and numerical skills from pupils. Attentional demands and the sequencing of lessons are under teacher control who attempts to suit the needs of the average student. Students who are above or below the average may find school boring and not enjoy success in achievement.

Biased IQ tests tend to measure the same verbal skills the classroom requires, and in order to achieve better prediction, often include performance items which the teacher feels measure what the student has learned. Thus a higher correlation of an IQ measure and achievement may indicate that the test has a verbal bias or is performance oriented.

Culture-reduced IQ tests attempt to measure skills other than those required for classroom success. These tests are less school performance oriented, attempting to measure innate skills which may not be utilized in the classroom because of the group situation and the amount of feedback to each student. Therefore a lower correlation between achievement and a culture-reduced IQ test would be expected since there is less reliance on verbal or performance skills and more on abilities not learned in school.

Another factor is the learning strategies employed by students. These cannot be uniquely monitored by the teacher who tends to prefer the strategy used by the majority of the students or even his own unique strategy. This results in maximum learning only for those students who also used the teacher's strategy, with perhaps interference and a lower level of achievement for those students employing alternate learning strategies. Thus the correlation of achievement with a culture-reduced IQ test will be lower under classroom instruction.

b. Under CAI Conditions

The degree to which a CAI program individualizes instruction to fit the needs of the learner will determine its success as a teaching mode. If the program allows and monitors several strategies, then more learning should result. Thus innate skills are being used and achievement may show higher correlations with a culture-reduced IQ measure, indicating prediction based on those skills not learned in the classroom.

If however the program is highly verbal with little flexibility for individual strategies, the learning situation will approach the group situation of the classroom, perhaps resulting in a lower correlation of achievement with a culture-reduced IQ measure.

Finally if the correlation between a culture-reduced IQ measure and classroom achievement is low, then the classroom environment may reflect components not related to the more innate potential of the students. This is independent of absolute levels of achievement (means). If however the correlation for the culture-reduced measure and the CAI achievement is high, then the components of the students which are less dependent on previous schooling are more highly related to those components required for achievement under CAI instruction.

These relationships imply that a more individualized instructional environment has been attained when culture-reduced IQ measures are highly related to achievement, whether instruction is in the classroom or under CAI conditions.

Achievement and Attitude Measures

Although correlations between attitudes and achievement tend to be positive and account for less than twenty percent of the variance (Gilman and Brown, 1967), perhaps the student-subject matter interaction may partially affect the student's attitude towards a subject. This could be important for long range uses of CAI.

General Statement of the Problem

The problem investigated was the relationship between intelligence and achievement when a computer was used to individualize instruction for a group of pupils. Is the achievement related to the ability of the pupil as determined by standardized intelligence tests? How do achievement scores compare with achievement produced under conventional classroom instruction? Finally does a student's attitude towards a subject change when instructed by a computer?

Delimitations

The study was restricted to a random sample of pupils selected from four grade eight classes in two Junior High Schools which have a broad range of socio-economic levels located in the City of Edmonton. The results from the experimental group were compared to a randomly selected control group taught in the conventional classroom.

The course content covered is outlined in the Alberta Department of Education Science Curriculum (1962) on magnetism and electricity. The duration of instruction was about four weeks. Both groups studied the same course topics (Appendix 1) with new unrelated subject-matter being taught when all students were back in the classroom after the experimental period. This was done to minimize overlearning and/or interference with course topics already taught.

If student-subject attitudes were influenced by former experiences with the subject and teachers, these could have been transferred in varying degrees to the science classes involved in the experiment. Controlling for subject matter, any changes in attitudes may then be the result of the teaching technique. Thus the computer-student and teacher-student interactions may have resulted in changes of attitudes towards the subject. Unfortunately both groups had attitudes from former experiences which tended to confound the attitude measures toward the subject being taught. Though these were not controlled, they were recognized as confounding variables in the experiment.

CHAPTER IV

THE EXPERIMENTAL DESIGN AND STATISTICAL PROCEDURES

The CAI Program

An experimental approach was used with a set of laboratory apparatus available at each student station allowing each student to perform each experiment individually. Instructions how to use the apparatus were given to each student and no time limit was placed on the amount of time a student required to perform an experiment. When he had finished the method part, he pressed the space bar and received three multiple choice questions from which he selected his observations with the light pen. If he selected the correct observation the conclusions were then presented in the form of three or four blanks to be completed by typing in the answers.

For the observations and conclusions, each answer requested was allowed three tries for the correct answer. For each wrong answer a message was displayed along with a hint, or for observations, perhaps a suggestion to repeat the experiment again. After three or more wrong answers, the student was told the correct answer which had to be put into the system by the student before being allowed to proceed with the next question or experiment. The conclusions were copied into the student's notebook so he would have some record of what was done when he returned to the classroom. Performance recordings were made so every answer the student supplied was recorded as well as the number and sequence of his responses for each question. Flow diagrams illustrating this strategy and an example of what the student saw are given in Appendix 2.

All students performed the same experiments but at different rates of speed depending on their ability to perform the experiments and answer the questions. Reinforcement consisted of knowledge of response-adequacy and verbal praise for good performance. The emphasis was on positive reinforcement only.

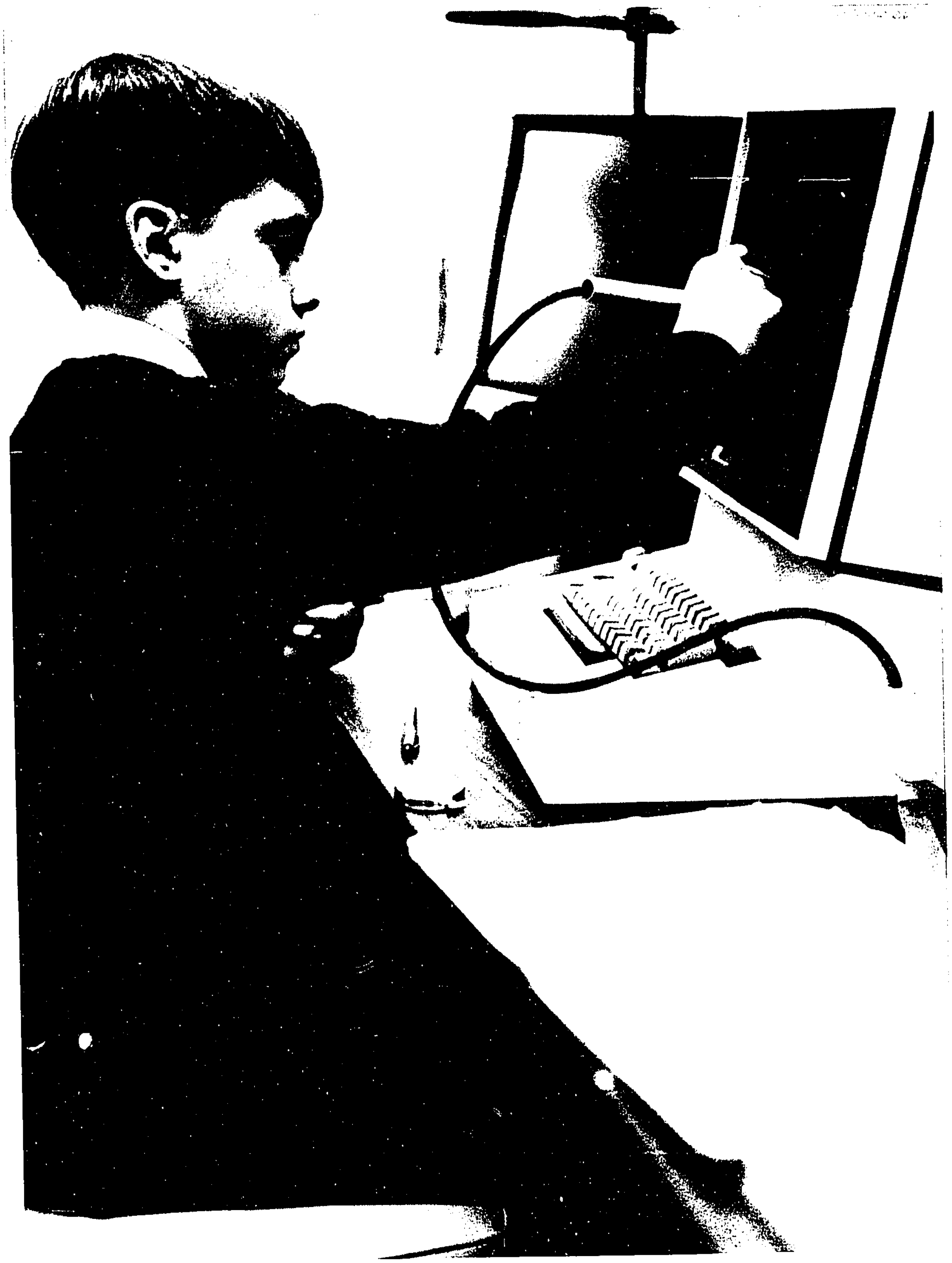
Subject matter was magnetism, static and current electricity as outlined in the Alberta Science Curriculum (1962) for grade eight (Appendix 1). The course was integrated with the same classroom text used by the teacher with the control groups. A number of experiments using laboratory equipment were performed by the experimental group individually. These also were performed in the classroom at the teacher's discretion.

The Teaching Computer Hardware

Eight student starions were used simultaneously with one central computer in the Education Building, University of Alberta. Each station consisted of cathode-ray tube (CRT) for displaying verbal or graphic materials, a random access projector with a magazine for 1000 pictures, and a typewriter keyboard along with a light pen for input responses. These are shown in the picture on the following page. Audio facilities were not available.

Attitude Measures

To measure attitude changes if any, a pretest of attitudes



attempted to measure these for each student in the control and experimental groups. After the experimental period, a posttest for each group determined if any changes occurred in student attitudes towards the subject during the experimental period.

The Measuring Instruments

Students in the Edmonton Public System will have received at least two standardized intelligence tests by the time they reach grade eight. Assuming that the earlier test(s) have less reliability (Cronbach, 1960) the value of the last test (Lorge-Thorndike) was used for each student.

The Lorge-Thorndike Intelligence Test was examined by Elley (1961) for grade seven students. He found a high 'g' loading and negligible group factor loadings, particularly the figure analogies test. The test was rated equal to the Progressive Matrices Test as being culturally reduced. The correlation with reading, arithmetic and English achievement tests was .47 but the numerical test suggested more dependence on environmental aquisition than is desirable.

Since mathematics played almost no role in the science material being taught, the numerical bias of the test should not affect this study although it may have distorted the IQ scores slightly.

F. S. Freeman in Buros (1959, P478-480) reviewed the test and reported reliability ranges from .70 to .90 with verbal scales averaging .87. Concurrent validity with the Stanford grade equivalent and congruent validity are specified as .87 and .74 respectively with the reviewer's support for construct validity.

The biased intelligence test was the Otis Quick-Scoring Mental Ability Test, form Beta. The test manual reports reliabilities based on odd versus even items, corrected by the Spearnman-Brown Formula, as .86 for grade eight and ranging from .79 to .92 for other grades. Correlations with the Stanford Achievement Test, form J for grade eight students ranged from .62 to .82.

Lefever, a reviewer of the Otis test in Buros (1959, P362) observed that more than two thirds of the items measure verbal competence, and thus is a good predictor of school success. No correlations however were stated either by him or in the manual. The manual does discuss the selection of items as being based on the success by rapidly progressing students with the success of slowly progressing students. Thus each item measures intelligence as reflected in the rate of progress through school.

Lefever states,

> "Abilities of the pupil whose interests and talents are distinctly along 'non-bookish' lines may be incorrectly appraised" Buros 1959, P362).

Thus the Otis Test may discriminate against low verbal competence and hence is a biased intelligence test.

The achievement of the students was measured by two parallel tests on magnetism and electricity. One test prepared by S. Bruder (Appendix 4) was used for the pre- and first posttest. The other test by G. Luck (Appendix 5) was used for the two-week later posttest.

The two test authors reported reliabilities of .81 and .87 respectively as determined by Kuder-Richardson formula 20. A Chi-Square test of independence (Ferguson 1966, P200) did not reject the null hypothesis at the .05 level that the frequency distributions were no different. Using the statistical criterion for parallel tests (Gulliksen, 1950, P173) the variances of the two tests were not significantly different ($P < .01$) but the means were significantly different. Since the study is of a correlational nature, the difference in means is not important.

The attitude instruments by Silance and Rommers explore a school subjects with forms A and B. Form A was the pretest and form B was the posttest. Shaw and Wright (1967) reported a reliability of .81 to .90 and the scale has been validated using criterion groups measured for interests and values (Appendixes 6 and 7).

The instrument for measuring the time the student required to complete the course is part of the computer. Every time a student signed on or off, the time was recorded on a performance disk. On the same disk a daily record of progress, the type and number of responses were also stored which were later printed out for analysis by the author.

<u>Sampling and Testing Procedures</u>

A random sample from three average grade eight classes was brought to the computer four times per week so the number of periods of science received by both groups was the same.

The three experimental groups of eight students were from Garneau School and those students not selected for the experimental group were taught the same subject matter by the teacher in a conventional classroom.

To reduce the problem of teacher bias, another class in Allendale Junior High School was used as a control group taught by another teacher. The two schools have the same broad socio-economic backgrounds, hence equivalent student populations. With two teachers, there was more possibility of teacher variables balancing out so a more representative group was obtained taught by conventional classroom techniques.

In one classroom for each teacher, a tape recorder was used under the control of the teacher to provide a measure of the classroom instructional techniques used by the two teachers. If there were large differences in achievement or attitudes for each teacher, a record was available to confirm the subject matter and its presentation to the classroom groups. The fact that a lesson was to be recorded may also have encouraged a teacher to do his best. There were no significant differences however in achievement or attitudes between schools and the tape recorders confirmed that both teachers did cover the required topics on which the students were tested.

The computer program also confirmed that the course topics were presented to the students on which the two posttests were based. (See Appendix 1)

Winer (1962, P104) enabled a minimum sample size to be estimated. With two treatments, a mean difference of five standard units, and a power of .90, the minimum sample size is twelve at the .05 significance level. At the .01 level, the sample size is nineteen. Eight pupils were randomly selected from each of three classes, then the total of twenty-four was an adequate sample. The sample size was estimated to support the parametric tests on achievement.

All students were given pretests of achievement and attitudes towards the subject. After almost four weeks of instruction, each student was given a post-achievement and attitude test. After returning to the classroom, both groups received classroom instruction in new topics to minimize contamination of former learning. Two weeks later, another achievement test was administered to both groups. For all students, the first posttest was administered as part of the Christmas Science Exam written in the classroom.

The initial post-achievement test enabled a measure of what had been learned to be established for both groups. The test two-weeks later measured retention for both groups.

In correlating achievement and IQ for each group, it was expected that the individualization of instruction to each student by CAI would reduce the variance on the first post-achievement test so the correlation with IQ would be meaningless. However, after two weeks the variances for both groups were expected to change and a more meaningful correlation would result for the CAI group. This anticipated problem did not occur however and correlations were interpreted for both posttests and IQ.

The control group was much larger than the experimental group. For comparison, twenty-four students were randomly selected from the four control classes. This was done after all testing to ensure that teachers and the experimenter would not know which individual students would be compared with the experimental group.

<u>The Null Hypotheses Tested</u>

The data gathered from the testing program described on the preceding pages were used to test the following null hypotheses:

Null Hypothesis 1. The correlation of ability as measured by the Otis Intelligence Test and the second posttest of achievement for the computer-instructed pupils is not significantly different from that of the regular classroom pupils.

Null Hypothesis 2. The correlation of ability as measured by the Lorge-Thorndike Intelligence Test and the second achievement posttest for the computer-instructed pupils is not significantly different from that of the regular classroom pupils.

Null Hypothesis 3. The correlation of ability as measured by the Otis Intelligence Test and the second achievement posttest is not significantly different from the correlation of ability as measured by the Lorge-Thorndike Intelligence Test and the second achievement posttest for the control group.

Null Hypothesis 4. The correlation of ability as measured by the Otis Intelligence Test and the second achievement posttest is not significantly different from the correlation of ability as measured by the Lorge-Thorndike Intelligence Test and second posttest achievement for the CAI group.

Null Hypothesis 5. The variances of the two populations are not significantly different from each other as a result of the treatments with respect to achievement based on the first posttest.

Null Hypothsis 6. There is no significant difference between the population achievement means for control and experimental groups as a result of treatments.

Null Hypothesis 7. There is no significant difference in the median hours of instruction required for the experimental and control populations to complete the course topics required.

Null Hypothesis 8. There is no significant change in the median attitude of the experimental and control populations as a result of the treatments given.

The Statistical Procedures

All statistical analyses were done using on-line terminals with the University of Alberta digital computer. The procedures used to analyze the data are described in the following paragraphs.

Null hypothesis 1 was tested by correlating the Otis Quick-Scoring Intelligence Test scores and the second posttest achievement scores for the experimental and control groups. The difference between the two correlation coefficients was tested for significance (Ferguson 1966, P188).

To test null hypothesis 2, ability or IQ scores for the Lorge-Thorndike Intelligence Test were obtained from school records and correlated with the second posttest achievement scores for the control and experimental groups. The difference between the two correlation coefficients was tested for significance (Ferguson 1966, P187).

In testing null hypothesis 3, intelligence scores obtained from the Otis Intelligence Test and the Lorge-Thorndike Intelligence were correlated with the second posttest achievement scores for the control group. The difference between the two correlation coefficients was tested for significance (Ferguson 1966, P188).

Null hypothesis 4 was tested by correlating the second posttest achievement scores for the experimental group with the Otis Intelligence Test Scores and the Lorge-Thorndike Intelligence Test Scores. The difference between the two correlation coefficients was tested for significance (Ferguson 1966, P188).

In testing null hypothesis 5, the variance of the post-achievement scores for both groups was compared by the F ratio (Ferguson 1966, P183) using a two-tailed test and the .02 level of significance. This was done for each of the two posttests. Whether the variance changed for each group over the two-week period was also tested for significance (Ferguson 1966, P183).

For null hypothesis 6, an analysis of covariance (Winer 1962, P578) compared the first posttest achievement scores for the two treatment groups after adjustment was made for the covariate (pretest scores) at the .05 level of significance. Tests were made for within class and overall regression homogeneity. The F test is robust with respect to violations of normality and homogeneity of variance, so these were not tested (Winer 1962, P586).

For null hypothesis 7, the time required to complete the course of specified topics was reported by the classroom teachers. The total numbers of hours for the computer group was obtained from the performance disk and the median hours established. These two times were compared on a percentage basis.

To test null hypothesis 8, a 3-way Factorial Analysis of Variance (Winer 1962, P248) examined the main effects of factors A(sex), B(treatment) and C (test) and their interactions. Tests for simple effects were also used (Winer 1962, P256) for the levels of each category.

CHAPTER V

INTERPRETATION OF THE DATA

In this chapter the results of the investigation are presented in four parts. Part A records relationships between intelligence measures and achievement. Part B examines the achievement of the same two groups from the standpoints of means, variances and sex differences. Part C involves the time given each group for instruction on the course material, while part D contains the findings from the attitude measures for the CAI and classroom groups, each consisting of 23 students. One student in the experimental group was absent for the first achievement posttest thus reducing the CAI group by one from the original 24.

A. RELATIONSHIPS BETWEEN INTELLIGENCE AND ACHIEVEMENT

Biased Intelligence Measures and Achievement

Hypothesis 1 involves the CAI and classroom correlation coefficients for the Otis Intelligence Test and the second posttest achievement scores. From table 1, neither the second nor the first posttest correlated significantly different with the Otis scores for the two groups. Thus the null hypothesis cannot be rejected and there is no significant difference between the correlation coefficients for the CAI and classroom groups. Both tests supported the trend for the classroom group to have a higher correlation between the Otis IQ measure and achievement.

A further analysis by sex (table 1) also did not show any significant differences but did further support the trend for the classroom group to have a higher correlation with the Otis IQ.

TABLE 1

CORRELATIONS OF ACHIEVEMENT AND OTIS IQ

Group	N	Pretest	First Posttest	Second Posttest
CAI	23	.195	.304	.384
Classroom	23	.401*	.604*	.675*
Males				
CAI	15	.022	.256	.448*
Classroom	11	.428	.652*	.628*
Females				
CAI	8	.800*	.446	.292
Classroom	12	.429	.703*	.452

* P<.05

Testing whether the correlation coefficients were significantly different from zero (Ferguson 1966, P186), the classroom group had significant correlations on all three tests, while no test for the CAI group had a significant correlation. Among sexes, the classroom boys had significant correlations on both post-achievement tests, while the CAI boys had only the second posttest correlation significant. For girls, the trend was for the CAI females to decrease their correlation with each test, while the classroom girls increased it from the pretest value.

Culture-Reduced Intelligence Test and Achievement

Hypothesis 2 examines the CAI and classroom correlation coefficients for the Lorge-Thorndike Intelligence Test and the second post achievement test. From table 2, significantly different with the Lorge-Thorndike scores at the .05 level. A further test for sex differences between the correlations for the first and second achievement tests (Ferguson 1966, P188) also showed no significance. However, the trend for females favoured higher correlations for the CAI group on both posttests. For boys, the trend favoured higher correlations for the classroom group on both posttests.

Other trends between the first and second posttests were for the CAI groups to increase their correlations, and for the classroom groups to decrease their correlations in two out of three cases.

TABLE 2

CORRELATIONS OF ACHIEVEMENT AND LORGE-THORNDIKE IQ

Group	N	Pretest	First Posttest	Second Posttest
CAI	23	.169	.360	.555*
Classroom	23	.235	.462*	.399*
Males				
CAI	15	-.179	.310	.395
Classroom	11	.325	.571*	.471
Females				
CAI	8	.841*	.394	.770*
Classroom	12	-.057	.122	.158

* $P < .05$,

Testing whether the correlation coefficients were significantly different from zero (Ferguson 1966, P186) the classroom group had significant correlations on both posttests, while the CAI group had only the second posttest correlation significant. For males, only the classroom correlation with the first posttest was significant. For females, only the CAI group had significant correlations on the pretest and second posttest.

Intelligence Tests and the Classroom Group

Hypothesis 3 examines the correlation coefficients for the second achievement test with the Lorge-Thorndike and Otis Intelligence Tests for the classroom group. From table 3, there were no significant differences for the whole group at the .05 level. A further analysis by sex did show a significant difference for females at the .05 level. This trend is supported by both achievement tests which had higher correlations with the Otis Test, though only the correlation for the girls was significant.

TABLE 3

CORRELATIONS OF ACHIEVEMENT AND INTELLIGENCE TESTS FOR THE CLASSROOM GROUP

Group	First Test			Second Test		
	L-T	Otis	t	L-T	Otis	t
Classroom	.462	.604	.973	.399	.675	2.014
Males	.571	.652	.563	.471	.628	1.075
Females	.122	.704	2.496*	.158	.452	.952

*P<.05

Intelligence Tests and the CAI Group

Hypothesis 4 deals with the correlation coefficients for the second achievement test with the Otis and Lorge-Thorndike Intelligence Tests for the CAI group. From table 4, none of the correlation coefficients is significantly different at the .05 level. A further analysis

TABLE 4

CORRELATIONS OF ACHIEVEMENT AND INTELLIGENCE TESTS FOR THE CAI GROUP

Group	First Test			Second Test		
	L-T	Otis	t	L-T	Otis	t
CAI	.360	.304	.256	.555	.384	.876
Males	.310	.256	.349	.395	.448	.371
Females	.394	.446	.156	.770	.292	2.039

$t_{.05}(20) = 2.086$ $t_{.05}(11) = 2.201$ $t_{.05}(6) = 2.45$

by sex also revealed no significant differences. The trend however favours higher correlations with the Lorge-Thorndike Test since four out of the six pairs of correlations show this, though none significantly.

B. ACHIEVEMENT

Achievement for the Classroom Population

A comparison of the two school groups for possible achievement differences is shown in table 5. There were no significant differences in achievement means between the two schools on the pretest, first posttest, or second posttest. Thus there was a common population from which the classroom control group was selected.

TABLE 5

ACHIEVEMENT MEANS AND STANDARD DEVIATIONS FOR BOTH CLASSROOM GROUPS

Group		Pretest	1st Post Test	2nd Post Test	N
Garneau	mean	17.68	26.56	25.94	46
	s.d.	4.17	6.03	6.97	
Allendale	mean	17.40	26.70	23.97	32
	s.d.	4.03	6.65	5.52	

Comparisons of Means for CAI and Classroom Groups

Means and standard deviations for the CAI and classroom groups appear in table 6. These are graphically represented in figures 1, 2 and 3.

A glance at figure 1 suggests superior achievement on all three achievement tests for the classroom group.

TABLE 6

ACHIEVEMENT MEANS AND STANDARD DEVIATIONS OF CAI AND CLASSROOM GROUPS

Group		Pretest	1st Post Test	2nd Post Test	N
CAI	mean	17.39	25.04	24.30	23
	s.d.	2.92	6.05	6.00	
Classroom	mean	18.57	28.78	27.43	23
	s.d.	4.28	5.02	5.49	
Males					
CAI	mean	18.0	26.64	26.0	15
	s.d.	3.14	5.08	5.16	
Classroom	mean	18.91	30.18	27.0	11
	s.d.	5.47	5.93	6.12	
Females					
CAI	mean	16.44	22.55	21.67	8
	s.d.	2.40	6.88	6.56	
Classroom	mean	18.25	27.50	25.25	12
	s.d.	3.05	3.83	3.65	

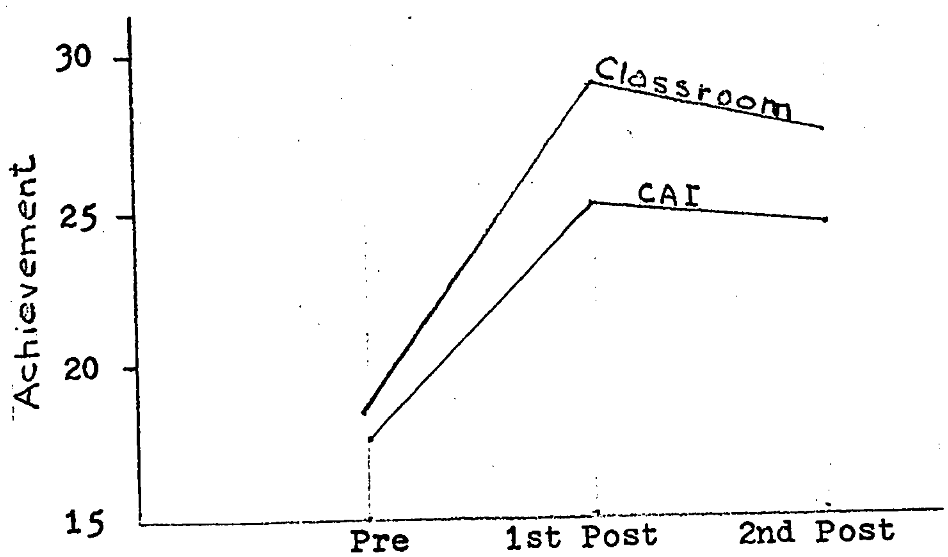


FIGURE 1

THE RELATIONSHIP BETWEEN ACHIEVEMENT MEANS AND TESTING OCCASION FOR BOTH GROUPS

TABLE 7

't' TEST FOR SIGNIFICANCE OF ACHIEVEMENT MEANS OF PRE AND POSTTESTS FOR BOTH GROUPS

Group	Mean	Pretest Classroom 't'	1st Posttest CAI 't'	1st Posttest Classroom 't'	2nd Posttest CAI 't'	2nd Posttest Classroom 't'
Pretest						
CAI	17.39	1.09	6.45**	--	--	--
Classroom	18.58	--	--	13.59**	--	--
1st Posttest						
CAI	25.04		--	2.28*	--	--
Classroom	28.78			--	--	--
2nd Posttest						
CAI	24.30				--	1.84
Classroom	27.43					--

*P <.05 **P <.01

From table 7, the following conclusions are drawn:

a. Significant gains for the CAI group between the pretest and the first posttest at the .01 level (t=6.45).

b. Significant gains for the classroom group between the pretest and the first posttest at the .01 level (t=13.59).

c. Significant difference between both groups on the first posttest at the .05 level (t=2.28).

d. No significant differences between both groups on the pretest and the second posttests at the .05 level (t=1.09, t=1.84).

Both groups were equivalent on the pretest, but the classroom group achieved significantly higher on the first posttest. This achievement superiority was not retained however because both groups were not significantly different on the second posttest.

Comparisons of Means for Both Groups by Sex

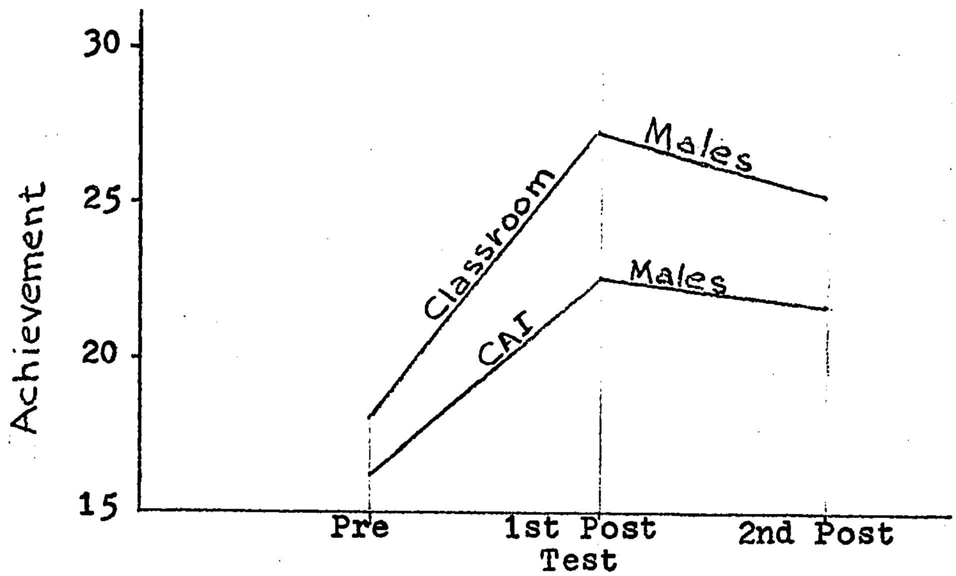


FIGURE 2

THE RELATIONSHIP BETWEEN ACHIEVEMENT MEANS AND TESTING OCCASIONS FOR MALES OF BOTH GROUPS

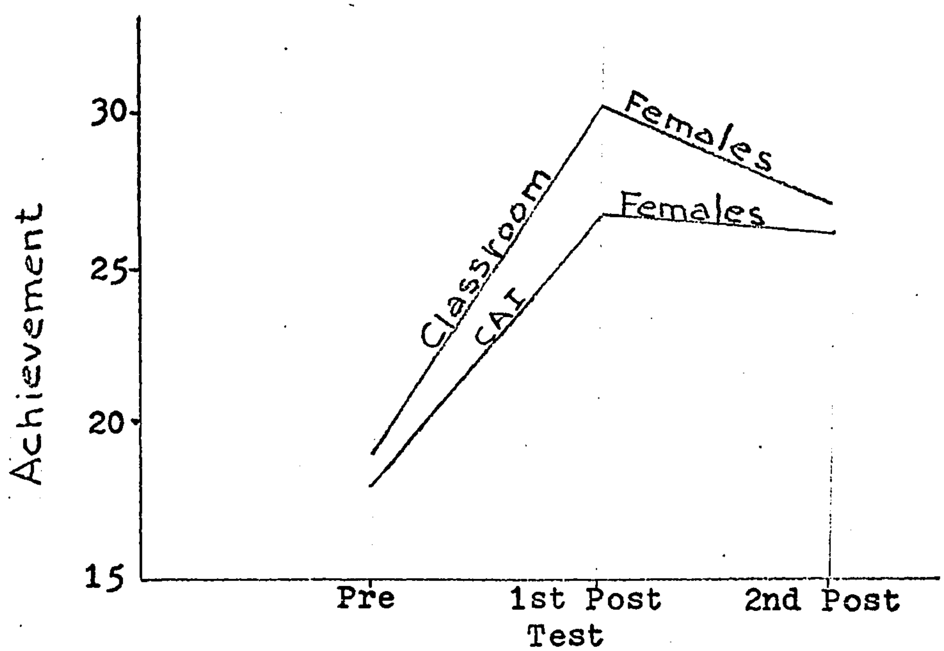


FIGURE 3

THE RELATIONSHIP BETWEEN ACHIEVEMENT MEANS AND TESTING OCCASIONS FOR FEMALES OF BOTH GROUPS

Figures 2 and 3 compare the achievement of the two groups by sex. Again both males and females in the classroom group appear to have higher achievement on all three tests. The loss for the classroom groups between the first and second posttests appears to be greater than for the CAI groups.

TABLE 8

't' TEST FOR SIGNIFICANCE OF ACHIEVEMENT MEANS OF PRE AND POSTTEST FOR MALES OF BOTH GROUPS

Group	Mean	Pretest Classroom 't'	1st Posttest CAI 't'	1st Posttest Classroom 't'	2nd Posttest CAI 't'	2nd Posttest Classroom 't'
Pretest						
CAI	18.0	.52	6.10**	--	--	--
Classroom	18.91	--	--	8.86**	--	--
1st Posttest						
CAI	26.64		--	1.61	--	--
Classroom	30.18			--	--	--
2nd Posttest						
CAI	26.0				--	.44
Classroom	27.0					--

*P <.05 **P <.01

From table 8 the following conclusions are drawn:

a. Significant gains were made by the CAI group between the pretest and the first posttest at the .01 level (t=6.10).

b. Significant gains were made by the classroom group between the pretest and the first posttest at the .01 level (t=8.86).

c. No significant differences between males of the two groups at each of the three testing periods at the .05 level (t=.52, t=1.61, t=.44).

TABLE 9

't' TEST FOR SIGNIFICANCE OF ACHIEVEMENT MEANS OF PRE AND POSTTESTS FOR FEMALES OF BOTH GROUPS

Group	Mean	Pretest Classroom 't'	1st Posttest CAI 't'	1st Posttest Classroom 't'	2nd Posttest CAI 't'	2nd Posttest Classroom 't'
Pretest						
CAI	16.44	1.46	2.93*	--	--	--
Classroom	18.25	--	--	11.58**	--	--
1st Posttest						
CAI	22.55		--	2.10*	--	--
Classroom				--	--	--
2nd Posttest						
CAI	21.67				--	1.56
Classroom	25.25					--

$*P<.05$ $**P<.01$

For the females of both groups, tests for significance of achievement are shown in table 9. The following conclusions are drawn:

a. Significant gains over pretest scores for the CAI group on the first posttest at the .05 level (t=2.93).

b. Significant gains over pretest scores for the classroom group on the first posttest at the .01 level (t=11.58).

c. A significant difference between the females in the CAI and classroom groups on the first posttest at the .05 level (t=2.10).

For females, both groups were not significantly different on the pretest but the classroom group achieved significantly higher on the first posttest. This superiority however was not retained as both groups were again not significantly different on the second posttest.

Achievement on the First Posttest

Hypothesis 6 examines the first post-achievement tests for the CAI and classroom groups after adjustment has been made for the pretest scores (Winer 1962, P578). Testing for within class and overall regression homogeneity (Winer 1962, P587), no significant departures from homogeneity of linear regression were found (table10).

TABLE 10

TEST FOR ASSUMPTIONS OF LINEAR REGRESSION FOR ANALYSIS OF COVARIANCE

Regression Class	Data	Tables
Within	F = .042	$F_{.95}(1,42) = 4.07$
Overall	F = 1.90	$F_{.95}(2,42) = 3.22$

The analysis of covariance results (table 11) indicate that the null hypothesis cannot be rejected. Thus there is no significant difference in achievement between the CAI and classroom groups on the first posttest of achievement at the .05 level when statistical control is provided by the pretest.

TABLE 11

ANALYSIS OF COVARIANCE OF ACHIEVEMENT SCORES FOR CAI AND CLASSROOM GROUPS

Source	SS	df	MS	F
Total	1063.98	45		
Error	976.49	44	22.71	
Treatment	87.49	1	87.49	3.85

$F_{.95}(1,44) = 4.06$

Sex Differences in Achievement

The possibility of sex differences in achievement was examined using a 2 by 2 factorial design, analysis of covariance (Winer 1962, P595). The two categories were male and female (P=2) while the two treatments were the CAI and classroom groups (Q=2) with the pretest achievement as the covariate. From table 12, the null hypothesis cannot be rejected for sex differences, for treatment differences nor for interaction effects, all at the .05 level.

TABLE 12

2 X 2 ANALYSIS OF COVARIANCE OF THE FIRST POSTTEST ACHIEVEMENT SCORES FOR CAI AND CLASSROOM GROUPS

Source	SS	df	MS	F
Sex (A)	50.31	1	50.31	2.22
Treatments (B)	89.36	1	89.36	3.94
A X B	5.13	1	5.13	.23
Error	904.03	40	22.69	

$F_{.95}(1,40) = 4.08$

The Relation of Ability Levels and Achievement

A final 3 by 2 analysis of covariance was made on the basis of intellectual ability as measured by the Lorge-Thorndike Intelligence Test and the first performance test, for the CAI and classroom groups. Using the pretest as covariate, the three categories were high (IQ≥122), medium (IQ=112-121), and low (IQ≤111). These arbitrary limits were selected to have approximately equal numbers in the cells.

TABLE 13

3 X 2 ANALYSIS OF COVARIANCE OF ACHIEVEMENT SCORES FOR CAI AND CLASSROOM GROUPS

Source	SS	df	MS	F
Abilities (A)	129.06	2	64.53	2.89
Treatments (B)	81.47	1	81.47	3.65
A X B	55.51	2	27.75	1.24
Error	804.88		22.34	

$F_{.95}(2,36) = 3.26$ $F_{.95}(1,36) = 4.11$

From table 13, the null hypothesis could not be rejected for ability differences, for treatment differences, nor for interaction effects, all at the .05 level.

An analysis of simple main effects for each treatment group (Winer 1962, P581) revealed no significant differences between each level of ability for either the CAI or classroom group. However, from table 14, the classroom group almost reached significance at the .05 level. This was not the case for the CAI group suggesting a trend for more homogeneous achievement among the CAI ability groups.

TABLE 14

SIMPLE MAIN EFFECTS COMPARISON FOR THE INTELLIGENCE LEVEL CATEGORIES

Source	Calculated F Ratio	F Level for Significance
CAI	1.58	$F_{.95}(2,19)=3.52$
Classroom	3.39	

A further analysis of simple main effects for each of the three categories (Winer 1962, P581) revealed no significant differences for the high and medium levels of ability, but there was a significant difference for low ability groups a shown in table15. This was in favour of the classroom group.

TABLE 15

ANALYSIS OF COVARIANCE OF ACHIEVEMENT SCORES FOR LOW ABILITY CAI AND CLASSROOM GROUPS

Source	SS	df	MS	F
Total	175.06	9		
Error	96.74	8	12.09	
Treatment	78.32	1	78.32	6.48*

*$P < .05$ $F_{.95}(1,8) = 5.32$

A comparison of mean IQ levels for each of the three categories showed no significant differences for the high and medium levels, but a significant difference in IQ was found for the low level favouring the CAI group. Thus even with slightly higher ability, the low IQ CAI group could not achieve to the same level as the low IQ classroom group (table16).

TABLE 16

't' TEST FOR SIGNIFICANCE OF MEAN IQ FOR THREE ABILITY LEVELS

Group	Mean	't'
High		
CAI	125.75	1.17
Classroom	128.29	
Medium		
CAI	116.67	0.64
Classroom	115.91	
Low		
CAI	109.5	4.93**
Classroom	104.2	

**p .01

Achievement Variances for CAI and Classroom Groups

Hypothesis 5 examines the variances of the first and second achievement tests within and between the CAI and classroom groups (Ferguson 1966, P183). The null hypothesis cannot be rejected for any pair of variances, so there is no significant difference within or between the variances of the two achievement tests for both groups (table 17).

TABLE 17

TEST FOR SIGNIFICANCE OF ACHIEVEMENT VARIANCES FOR BOTH GROUPS

Group	Post Achievement Test	Variance	CAI 2nd Post Test	Classroom 1st Post Test	Classroom 2nd Post Test
CAI	1	36.59	t=.05	F=1.46	F=1.22
	2	36.04	--	F=1.44	F=1.20
Classroom	1	25.18		--	t= .54
	2	30.17			--

$t_{.05}(21) = 2.080$ $F_{.95}(22,22) = 2.05$

C. COURSE COMPLETION TIMES

Hypothesis 7 deals with the time in hours required to complete the course for the CAI and classroom groups. All three classrooms at school A were instructed by the same teacher and each received the same number of hours instruction. The one classroom at school B required slightly more time to complete the course topics (2 hours).

TABLE 18

TIME FOR CAI AND CLASSROOM GROUPS

Group	Median Hours	Percent of Classroom
CAI	6.93	59.2
Classroom	11.7	100.0

From table 18, the CAI group had a considerably shorter median period for instruction because the transportation time to and from the computer was lost instructional time. This was done to minimize the disruption to the regular school program of the CAI students. One student in the CAI group did not quite complete the program because of illness or absence. Completion times ranged from 5.85 to a maximum of 8.46 hours. In conclusion, the CAI group received less than 3/5 the time available for instruction relative to the classroom group.

D. ATTITUDES

Attitudes for the Classroom Population

Comparing the two school groups for possible attitude differences (table 19), no significant differences were found between the mean attitude scores for the Garneau (school A) or the Allendale (school B) classes. This supports the hypothesis that the school populations which were pooled for selection of the classroom control group were similar.

TABLE 19

ATTITUDE MEANS AND STANDARD DEVIATIONS
FOR GARNEAU AND ALLENDALE SCHOOLS

Group		Pretest	Posttest	N
Garneau	mean	7.77	6.58	40
	s.d.	1.42	2.17	
Allendale	mean	7.36	6.55	32
	s.d.	1.86	2.37	

Means and standard deviations of the experimental (CAI) and classroom groups appear in table 20. These are also represented graphically in figures 4 and 5, p.62.

TABLE 20

ATTITUDE MEANS AND STANDARD DEVIATIONS OF CAI AND CLASSROOM GROUPS

Group		Pretest	Posttest	N
CAI	mean	7.92	8.05	23
	s.d.	1.45	1.15	
Classroom	mean	7.29	6.43	23
	s.d.	2.04	2.28	
Males				
CAI	mean	7.68	7.73	15
	s.d.	1.75	1.29	
Classroom	mean	7.15	7.26	11
	s.d.	2.12	1.72	
Females				
CAI	mean	8.37	8.61	8
	s.d.	0.39	0.42	
Classroom	mean	7.41	5.68	12
	s.d.	2.04	2.53	

Attitude Differences for CAI and Classroom Groups

Hypothesis 1 involves testing for differences of the means of pre- and post-attitude scores for the two groups. Examining figure 4, the mean score for the CAI group increased slightly as a result of treatment, while the classroom mean decreased.

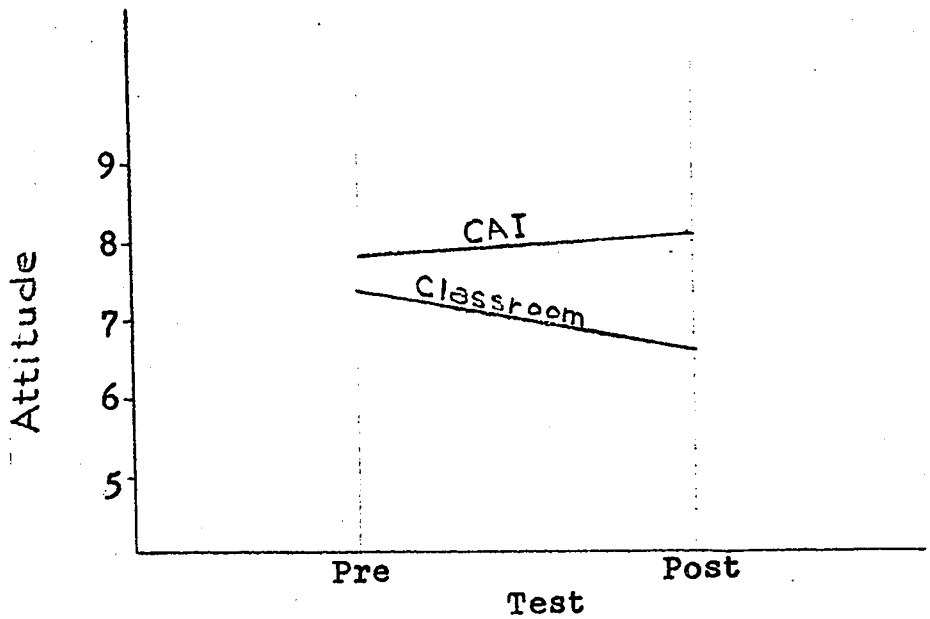


FIGURE 4

THE RELATIONSHIP BETWEEN TESTING OCCASION AND MEAN ATTITUDE SCORES FOR BOTH GROUPS

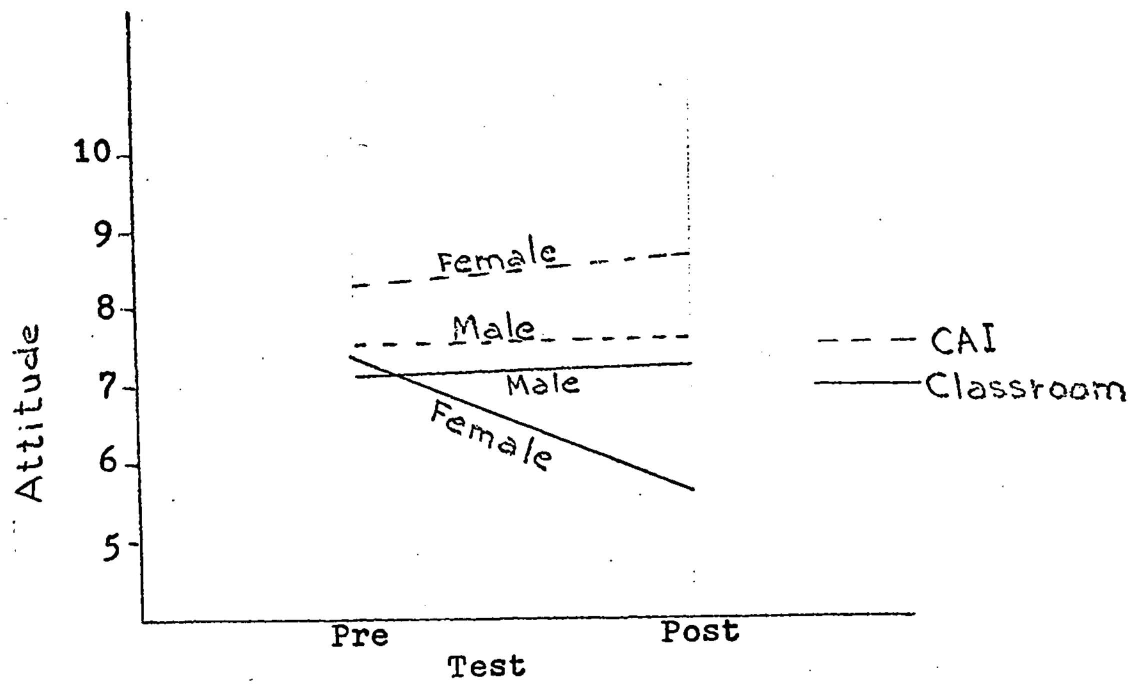


FIGURE 5

THE RELATIONSHIP BETWEEN TESTING OCCASION AND MEAN ATTITUDE SCORES FOR GROUPS BY SEX

Both classroom teachers reported that the girls did not like the subject matter so the analysis included sex differences for the two groups.

As shown in figure 5, only the classroom mean for females decreased as a result of the treatment. All other groups increased slightly on the posttest compared to the pretest.

From the 3-way Analysis of Variance summarized in table21, only the treatment main effects were significantly different. Thus there was a significant decrease in the attitudes of the classroom group compared to the CAI group at the .05 level.

TABLE 21

3-WAY ANALYSIS OF VARIANCE OF ATTITUDE SCORES FOR CAI AND CLASSROOM GROUPS

Source	SS	df	MS	F
A (sex)	.11	1	.11	.03
B (treatment)	32.59	1	32.59	10.58*
C (test)	2.51	1	2.51	.81
A X B	11.66	1	11.66	3.78
A X C	3.60	1	3.60	1.11
B X C	9.26	1	9.26	3.01
A X B X C	5.78	1	5.78	1.87
Within Cell	259.24	84	3.08	

$F_{.95}(1, 84) = 3.97$ $*P < .05$

An analysis of simple effects for male and female categories resulted in a significant difference only for the females (F=27.60, df=1,84). Thus the classroom girls' attitudes decreased significantly compared to the CAI girls as a result of treatments at the .05 level.

The simple effects analysis for CAI and classroom categories resulted in a significant difference only for the classroom group ($F=4.71$, $df=1,84$). Thus the classroom group's attitude decreased significantly at the .05 level from pretest to posttest.

Summary of the Differences Between Groups

A. Intelligence and Achievement

Correlations of the Otis Intelligence Test with the first and second achievement tests were not significantly different for the two groups nor for each sex group. The trend for higher correlations for the total classroom group as well as for males and females was also supported.

Correlations of the Lorge-Thorndike Intelligence Test with the first and second achievement tests were also not significantly different for the two groups nor for each sex group. The trends were for the correlations to increase from the first to the second test for all CAI groups, and decrease in two out of three cases for the classroom groups.

For the classroom group alone, comparison of the correlation coefficients on both achievement and intelligence tests showed no significant differences. A further analysis by sex produced a significantly higher correlation for the girls with the Otis test than for the Lorge-Thorndike on the first posttest only, but the trend was also supported on the second posttest. In every group (overall, males and females) the trend was for a higher correlation with the Otis test.

For the CAI group alone, correlation coefficients for both achievement and intelligence tests also showed no significant differences. The trend however was for the overall group and the females to have higher correlations with the Lorge-Thorndike on the first and second posttests than with the Otis.

B. Achievement

The CAI and classroom groups both achieved significantly higher mean scores on the first posttest compared to the pretest. Neither group was significantly different on the pretest, but on the first posttest, the classroom mean was significantly higher than the CAI mean. Two weeks later on the second posttest, the two groups were not significantly different.

For males of both groups there were significant gains over the pretest mean on the first posttest. For the classroom males, there was a significant decrease in mean achievement from the first to the second posttest. This was not the case for the CAI males who decreased slightly but not significantly.

For females of both groups there also were significant gains over the pretest mean on the first posttest. Again however, the classroom girls decreased significantly in mean achievement during the two week period between the first and second posttests. This was not the case for the CAI girls.

An analysis of covariance for the CAI and classroom groups found no significant differences in achievement on the first posttest. A 2 X 2 factorial analysis of covariance with male and female categories and the two treatments also failed to show significant differences for categories, treatments or interaction.

A final 3 X 2 analysis of covariance with high, medium and low categories of IQ and the two treatments also found no significant differences for categories, treatments or interaction. An analysis of simple effects for the two treatments revealed a significant difference in achievement only for the low ability groups in favour of the classroom group.

There were no significant differences within or between the variances of the first and second achievement tests for both groups.

Finally, with respect to the two school populations, there were no significant differences on the pretest or the two posttests of achievement.

C. Course Completion Times

The CAI group used only 60% of the time given to instruction for the classroom group .

D. Attitudes

For the classroom group the mean attitude score on the posttest decreased significantly from the mean of the pretest scores. A further analysis by sex revealed a significant decrease only for the females.

For the CAI group, there was no significant difference between pre- and post-attitude means. For each sex group also there was no significant difference between pre- and post-attitude means.

Comparing the classroom and CAI groups, the means were not significantly different on the pretest, but after the instruction period the means were significantly different. With respect to sex differences, neither males nor females of each group differed significantly on the pretest means. On the posttest however, the classroom female mean was significantly lower than the CAI female mean.

With respect to the two school populations, there were no significant differences on the pre- or posttests.

CHAPTER VI

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

I. Purpose of the Investigation

The purpose of the investigation was to examine the achievement of a group of students taught by a computer and relate this achievement to standardized intelligence measures. The review of the literature questioned whether measures of intelligence are related to the ability to learn. The confounding of environment and innate ability produces biased and culture-reduced intelligence tests with higher school prediction from the former since these measure skills usually stressed in school. The characteristics of machine-student interaction may reduce differences in achievement on the basis of IQ.

II. The Nature of the Investigation

Students from one achool were randomly assigned to CAI or classroom groups. At the same time a class from another school was used as a control to reduce teacher differences in the classroom group. All students were pretested and posttested on attitudes and achievement. Two weeks later a second posttest of achievement was given to all students. Biased and culture-reduced intelligence test scores were obtained prior to the instruction period.

III. Conclusions of the Investigation

The relationship of achievement to biased or culture-reduced intelligence tests produced only one significantly different correlation. The trends however were for the classroom achievement to correlate higher with the biased test and the CAI achievement to correlate higher with the culture-reduced test. This suggests that CAI may better utilize the abilities of the student as measured by culture-reduced tests, while the classroom better utilizes abilities and skills of students as measured by a biased intelligence test.

With respect to achievement, the classroom group appeared to achieve a higher mean score on the first posttest. However when adjustment was made on the pretest scores, there was no difference in achievement between the two groups. This disagrees with the results of Grubb and Selfridge (1963) whose CAI students achieved much higher than classroom students with a 90% reduction in time. In this experiment only a 40% reduction was reached by the CAI group compared to the classroom group. Even this time reduction may have handicapped the CAI low ability pupils, despite a slightly higher mean IQ for the CAI group.

No differences in achievement were found between boys or girls receiving CAI or classroom instruction. Thus there is no evidence that the computer reduces sex differences in achievement claimed by Suppes (1965c). Perhaps sex differences in the classroom are related to earlier grades where early maturers have an advantage, or during the teens when subject complexity requires skills peculiar to one sex or the other. The course given was largely descriptive so neither sex had an advantage.

Stolurow (1960b) and Blackman and Holden (1963) reported less variation in PI performance for different ability levels. However in this experiment there was no difference between the CAI and classroom group but the trend for less variation did favour the CAI group. One reason perhaps for this being only a trend was the shortage of time the CAI students had to review. The slower students had no time to review even once. One of the strengths of CAI is to enable review under control of the student. Only the fast students had any review at all. If more time had been available for the CAI group then perhaps their achievement would have been higher and more homogeneous.

Skinner (1968) criticized the aversive nature of the schools which contributes to a dislike for school and forgetting. The resulting decrease in attitude for the girls of the classroom group suggests support for Skinner, but this is contradicted by the boys who did not change their attitude in the classroom. This may simply be a dislike for the subject matter and may improve with new topics which the girls like. There is also the influence of the Hawthorne and novelty effects which tend to maintain the interest of the CAI group thus raising the attitude measures for them.

Riedesal and Sugdam (1967) warned of the time required to program a course. The author estimates that 50 hours were required for each hour of student instruction. This involved writing the course, programming, correcting and pretesting with six students from Parkallen school. Then revisions and final testing were done before the experiment was begun. The average student time required for completion was seven hours meaning 350 to 400 hours were spent by the author before the experiment was begun.

Few teachers can afford to devote approximately 50 times the instruction period to preparation, but this program could be used for <u>every grade eight student in Alberta</u>. Thus although expensive for one school, the time may be considerably less than that which all grade eight teachers would have to spend preparing their presentations for the same subject-matter.

IV <u>Recommendations for Future Research</u>

The experiment should be replicated with a larger CAI group to determine if achievement is more related to culture-reduced ability measures. The existing classroom does discriminate against various socio-economic groups. Can this be remedied by CAI?

What would achievement results be if the CAI group had equal time compared to the classroom group? If a course is completed once by CAI in 60% of the time, what are the effects of a 20% increase or a 40% increase? What criterion of performance is to be accepted before allowing a student to commence another course?

If a learner is given adequate opportunity to review as judged by him, will the variance of achievement scores decrease tending to support more homogeneous achievement?

Students in the CAI group used actual equipment to perform experiments under the direction of the computer. If these experiments were simulated by the computer without the equipment being handled by the students, would there be differences between the simulated and actual equipment groups? What are the advantages or disadvantages of computer-simulated experiments?

No audio facilities were used in the experiment. Would their use produce any differences in achievement compared to the non-audio group?

What techniques can be used by authors to decrease the time required to program a computer? The relatively simple program used in this experiment was very time consuming to author.

With more information being available to students from television, well illustrated texts and magazines, the role of the school as a supplier of factual knowledge is declining. Many children already know much course material but few teachers have the time to administer and mark pretests before teaching a topic. Even if teachers do pretest, this presents more problems of trying to suit the needs of many smaller diverse groups. With CAI each student can be pretested and then his place in the program is selected.

What would be the results of long term individualized instruction after three or four years? Presumably more learning would occur, but are there other side effects such as attitudes, costs, teacher-training and societal effects?

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APPENDIXES

UNIT II

ALBERTA CURRICULUM GUIDE FOR SCIENCE (1962)

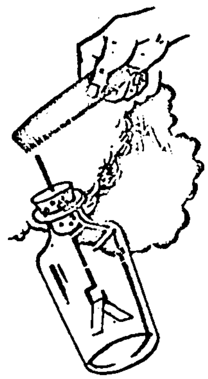
MAGNETISM AND ELECTRICITY

Content	Suggested Treatment
I. Magnetism	Read the story of the discovery of magnetism. A report on the work of Michael Faraday.
A. Natural magnets	Experiment: See *Science Activities, Book 2*, p. 129.
B. Artificial magnets, magnetic poles, keepers, magnetic fields, magnetic shielding	Experiment: Test materials for attraction and determine which are magnetic substances. Experiment: Shield the poles of a magnet with various substances and determine which prove to be the best for shielding.
C. Making artificial magnets	Experiment: Make a magnet (a) single touch method (b) double touch method (c) induction method (d) electro-magnetic method (Reserve for later).
D. Magnetic lines of force	Experiment: Using iron filing show the lines of force about a magnet. Use both bar and horseshoe magnet. Show the lines of force with the magnet in various positions e.g. like poles together, unlike poles etc.
E. The law of magnetic attraction and repulsion	Experiment: See *Science Activities, Book 2*, pp. 134-135.
F. The test for magnetism	Experiment: See *Science Activities, Book 2*, pp. 135-136.
G. The nature of magnetism 1. broken magnets (each part is a magnet) 2. molecular magnets	The experiments in *Science Activities, Book 2*, pp. 138-141 should be performed.
H. The destruction of magnetism	Experiment: (1) make a magnet, test and heat it, test again. (2) make a magnet, test it, and pound it, test again.
I. The earth as a magnet	Experiment: make a dipping needle and try it over a magnet. See *Science Activities, Book 2*, p. 144. Explain how the dipping needle is used to locate the magnetic poles of the earth.
J. The compass	Learn how to read a compass. Explain magnetic declination. Find the magnetic declination of your locality.
K. Everyday uses of permanent magnets	Try to find practical uses. (If possible bring some to class, e.g. pot-holders, can openers, toys, pad and pencils, tack hammers, etc.)
	Enrichment Suggestions: 1. All about Electricity (Freeman) E. N. Hale. 2. The Bright Design (Shippen) MacMillan. 3. Additional experiment. Show filmstrips.

UNIT II

MAGNETISM AND ELECTRICITY

Content	Suggested Treatment
II. Static Electricity (Electricity at Rest) A. Early history of static electricity	Reading and reporting about the experiments performed by Thales, Gilbert, Gray, duFay and Franklin.
B. Production of static electricity	Experiment: 1. Comb drawn through hair will pick up paper. 2. Comb rubbed on a wool sweater—same result. 3. Scuff feet on a wool rug—touch another person or metallic object. 4. Use an ebonite rod, glass rod, cat's fur, silk, small scraps of paper, sawdust. 5. Paper doll experiment.
C. Kinds of electrical charges	Experiment: Show that there are different kinds of electrical charges, and establish the law of electrical charges.
D. The pith-ball electroscope	Experiment: Study the use of the pith-ball electroscope.
E. The gold-leaf electroscope	Experiment: Study the gold-leaf electroscope and its use.
F. Conductors and insulators	Experiment: Distinguish between conductors and insulators.
G. Lightning	Discuss the nature of lightning.
H. Thunder	Discuss the nature of thunder.
I. The control of static electricity	Discuss the reasons for using lightning rods, chains from the frame to the ground on a gasoline truck, using care with dry cleaning materials, etc. Emphasize the importance of proper grounding of lightning rods.
III. Electricity at rest and in motion	Show filmstrips.
A. Relation between magnetism and electricity	
B. The magnetic field surrounding a conductor	Experiment: Is there a magnetic field about a wire carrying an electric current?
C. A conductor cutting the lines of force of a magnetic field	Experiment: Thrust a bar-magnet rapidly in and out of a coil of wire and test with a compass, and a galvanometer.
D. Electro-magnets	Experiment: Make an electro-magnet.
E. The strength of an electro-magnet	Experiment: With the above magnet (1) vary the number of turns of wire (2) vary the strength of the current.
F. The polarity of an electro-magnet (left-hand rule)	Experiment: Check polarity with a compass and by the left-hand rule.



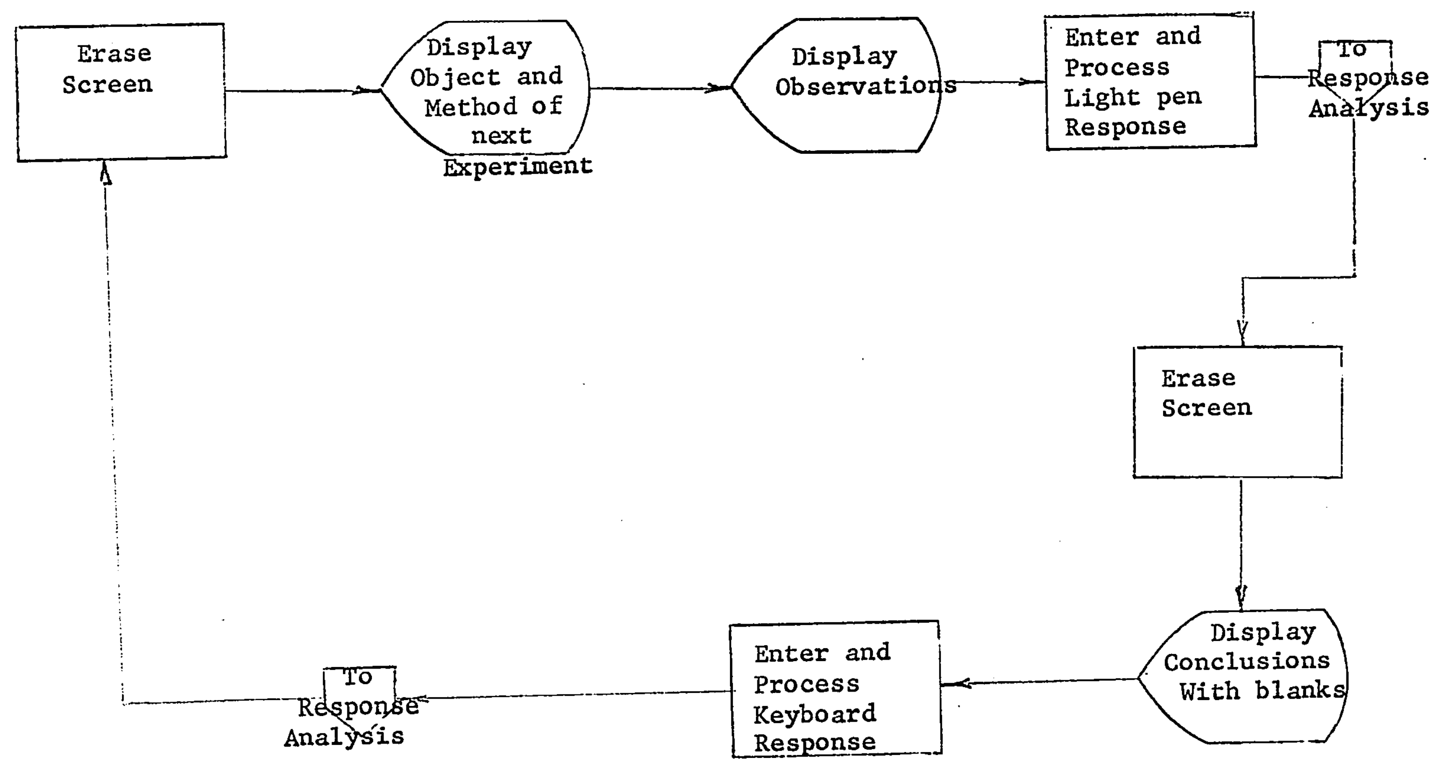
UNIT II

MAGNETISM AND ELECTRICITY

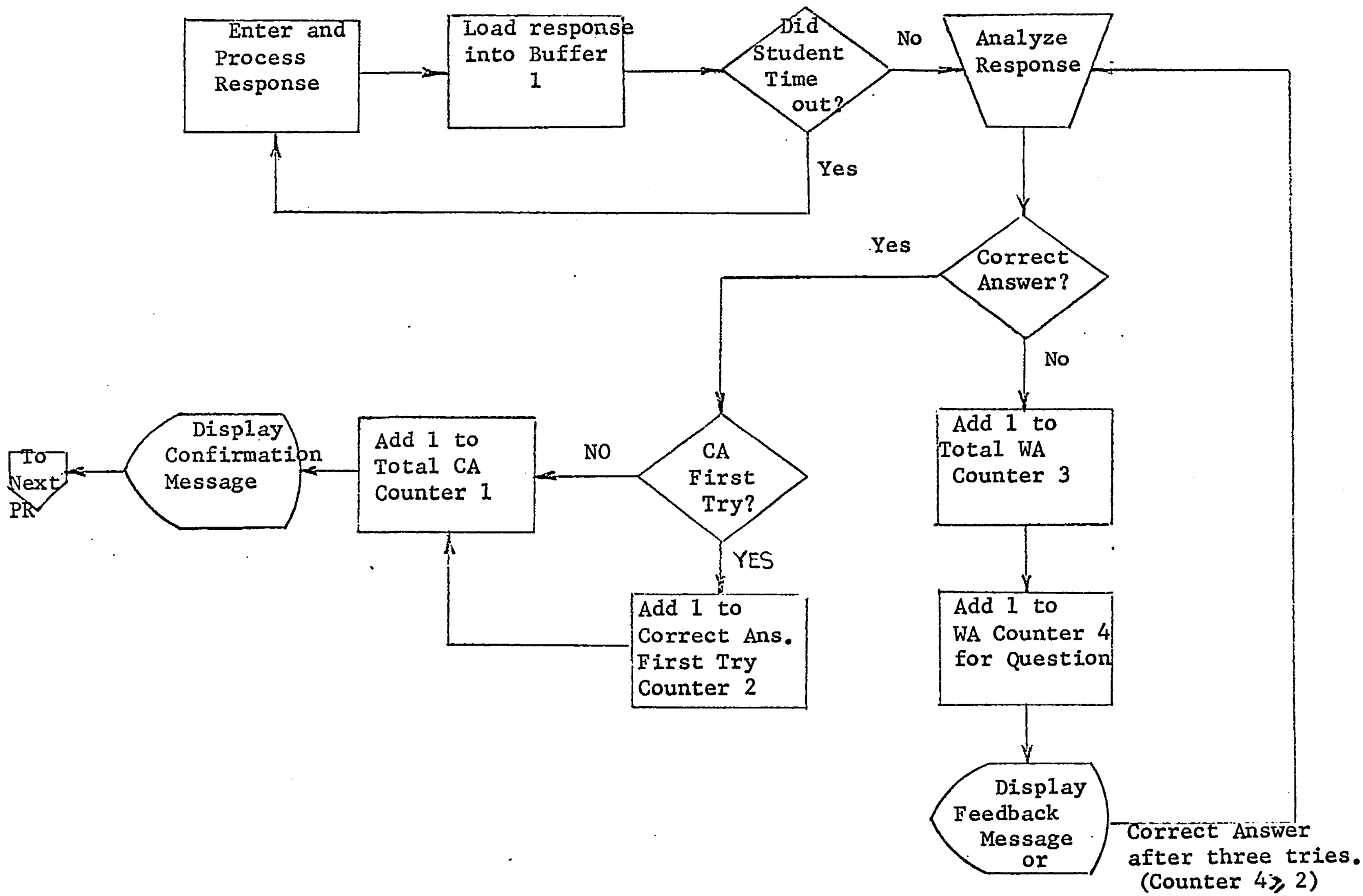
Content	Suggested Treatment
G. Uses of electro-magnets	(1) Examine an electric bell (buzzer). Make a well-labelled diagram indicating the essential parts. (2) Make a home-made telegraph set. (3) Examine the parts of a telephone. (4) A large diagram of each of the above for wall display. (5) Discuss other uses such as in flour mills (to remove metal from the flour) and in surgery (to remove metal from flesh). (6) Pupils' reports on the work of each of: Oersted, Ampere, Bell, Morse, Field and Bright. **Enrichment Suggestions: Construct an electric bell. Reading the Bright Design (Shippen). Build a model electric crane.**
IV. Electricity in Motion	
A. Current Electricity	Experiment: Construct a simple voltaic cell. Test for current flow with a galvanometer. Pupil Report: The work of Volta.
B. The electric circuit	Experiment: Connect an electric bell to two dry cells. Include switch in the circuit, open and close it.
C. Producing electricity chemically	Activity: Dismantle a dry cell and show the parts, (a large diagram for the class produced by a committee). A committee should produce a large diagram for wall display. Discuss the mercury cell.
D. A battery (2 or more cells)	Experiment: Set up two or more simple voltaic cells and connect in series. Test for current.
E. Storage battery	Activity: Dismantle a storage battery and show its parts (be careful of the chemicals). Show cells connected in series and in parallel.
F. An electric generator (dynamo)	Activities: Examine diagrams of simple generators. Explain the principle. Compare the voltage with water pressure. Explain commutator brushes. Use a hand-cranked dynamo. Dismantle an old generator. Pupil Report: The work of Michael Faraday.
G. Alternating and direct current	Explain the construction and use of the commutator.
H. A simple electric motor	Construct a simple electric motor.

APPENDIX 2

GENERAL FLOWCHART OF EXPERIMENTS



KEYBOARD AND LIGHT PEN RESPONSE ANALYSIS



A SAMPLE EXPERIMENT AS PRESENTED TO A STUDENT

Experiment 8

Is each part of a magnetized steel nail a magnet?

Apparatus and Material

A compass, a nail filed at the middle.

Method

Test the nail for magnetism with the compass. Magnetize the nail by stroking with the magnet at least 6 times. Establish whether the pointed end is a N or S pole. Then bend the nail back and forth until it breaks.

--PRESS SPACE BAR TO CONTINUE-- *

Test both pieces of the nail with the compass to determine whether each segment of the nail has a pole at one end only or at both ends.

Remember: Like poles repell, and unlike poles attract.

--PRESS SPACE BAR TO CONTINUE--

Observations (The student uses the light pen to answer)

Point to the statement which best describes what you observed.

X Each half of the nail had a pole only at one end.

X Each half of the nail had a pole at each end.

X Each half of the nail was no longer magnetized when broken apart.

* This message was at the bottom of the screen to separate each text section on the display CRT.

The following answer sequence was presented to the student depending on which of the three answers he selected:

1) the first answer-

"Wrong. Check your results and try again."

2) the second answer-

"Right. Each part of the nail became a smaller magnet. Continue."

3) the third answer-

"Have you ever seen a magnet with one pole? Try again."

4) If the student pointed to anyplace on the screen except the designated cursor location, he received the message-

"Point to the response square please. Try again."

5) After three tries, assuming all are wrong, the message was displayed-

"The answer is the second one."

After the student pointed to the correct answer, the screen was erased and the conclusions begun.

Conclusions

Type the word (retains, loses) which best fits.

If a magnet is cut into many smaller pieces, each segment _______ its magnetism.

If a molecule is the smallest segment of a magnet, perhaps it too _______ its magnetism.

The cursor was placed at the beginning of each blank anticipating an answer by the student.

For the first blank, if the student typed in any wrong answer, he received the message-

"Not quite. Check your spelling and try again."

If he typed in the correct answer, he received the message-

"Good. Now continue with the next blank."

If he failed to type in the correct answer after three tries, he received the message-

"The answer is retains. Type it in so you can continue."

For the second blank, if the student typed in any wrong answer, he received the message-

"Not quite. Check your spelling and try again."

If he typed in the correct answer, he received the message-

"Good. Now copy the conclusions into your notes under experiment 8."

If he failed to type in the correct answer after three tries, he received the message-

"The answer is retains. Type it in so you can continue."

After the correct answer was received for the last blank,

--PRESS SPACE BAR TO CONTINUE--

was displayed.

When the student had finished copying the conclusions into his notes, he pressed the space bar and the next experiment commenced.

```
ty a13/999
a13*e
de  0/32*e
dt  0,0/2,0/40,0/Experiment 8*e
dl  2,0/12*e
dt  3,5/2,3/40,0/Is each part of a magnetized steel*e
dt  5,0/2,5/40,0/nail a magnet?*e
dt  7,0/2,7/40,0/Apparatus and material*e
dl  9,0/22*e
dt  10,0/2,10/40,0/a compass,a nail filed at the middle.*e
dt  12,0/2,12/40,0/Method*e
dl  14,0/6*e
dt  15,5/2,15/40,0/Test the nail for magnetism with*e
dt  17,0/2,17/40,0/the compass. Magnetize the nail by*e
dt  19,0/2,19/40,0/stroking with the magnet at least*e
dt  21,0/2,21/40,0/6 times.*e
dt  23,0/2,23/40,0/Establish whether the pointed end is a*e
dt  25,0/2,25/40,0/N or S pole. Then bend the nail back*e
dt  27,0/2,27/40,0/and forth until it breaks.*e
no  macro dua007 april 68 tells student to press space bar to
, this allows time to read text/*e
#01#27*e
dt  30,4/2,30/40,0/--PRESS SPACE BAR TO CONTINUE--*e
epi 30,1/2,30/1,39/9999/1/zz*e
de  30/2*e
de  0/32*e
dt  0,0/2,0/40,0/Test both pieces of the nail with the*e
dt  2,0/2,2/40,0/compass to determine whether each*e
dt  4,0/2,4/40,0/segment of the nail has a pole at one*e
dt  6,0/2,6/40,0/end only, or at both ends.*e
dt  8,5/2,8/40,0/Remember: Like poles repell, and*e
dt  10,0/2,10/40,0/unlike poles attract.*e
no  macro dua007 april 68 tells student to press space bar to
, this allows time to read text/*e
#01#28*e
dt  30,4/2,30/40,0/--PRESS SPACE BAR TO CONTINUE--*e
epi 30,1/2,30/1,39/9999/1/zz*e
de  30/2*e
de  0/32*e
dt  0,0/2,0/40,0/Observations*e
dl  2,0/12*e
dt  3,5/2,3/40,0/Point to the statement which best*e
dt  5,0/2,5/40,0/describes what you observed.*e
dt  12,0/2,12/40,0/x Each half of the nail had a pole*e
dt  14,5/2,14/40,0/only at one end.*e
dt  16,0/2,16/40,0/x Each half of the nail had a pole*e
dt  18,5/2,18/40,0/at each end.*e
dt  20,0/2,20/40,0/x Each half of the nail was no longer*e
dt  22,5/2,22/40,0/magnetized when broken apart.*e
no  this is a light pen response sequence.
ld  0/c4*e
epp 200/pen8*e
ld  pen8/b1*e
nx  *e
br  re*e
#01#29*e
cap 2,16,2,0/cl*e
dt  26,0/2,26/40,0/ Right. Each part of the nail became*e
dt  28,0/2,28/40,0/a smaller magnet. Continue.*e
```

```
qu
 type control word
ty #01#29>55
#01#29*e
   1  cap 2,16,2,0✗cl*e
   2  dt  26,0✗2,26✗40,0✗ Right. Each part of the nail became*e
   3  dt  28,0✗2,28✗40,0✗a smaller magnet. Continue.*e
   4  pa  50*e
   5  br  prl✗c4✗ge✗l*e
   6  ad  l✗c2*e
#02#29*e
   1  wap 2,20,2,0✗wl*e
   2  br  #03#29✗c4✗ge✗3*e
   3  dt  26,0✗2,26✗40,0✗Wrong. Check your results*e
   4  dt  28,0✗2,28✗40,0✗and try again.*e
   5  ad  l✗c3*e
   6  ad  l✗c4*e
   7  pa  50*e
   8  de  26✗4*e
   9  wap 2,12,2,0✗w2*e
  10  br  #03#29✗c4✗ge✗3*e
  11  dt  26,0✗2,26✗40,0✗Have you ever seen a magnet*e
  12  dt  28,0✗2,28✗40,0✗with one pole? Try again.*e
  13  ad  l✗c3*e
  14  ad  l✗c4*e
  15  pa  50*e
  16  de  26✗4*e
  17  un  uu*e
  18  dt  26,0✗2,26✗40,0✗Point to the response square please.*e
  19  dt  28,0✗2,28✗40,0✗Try again.*e
  20  ad  l✗c3*e
  21  pa  50*e
  22  de  26✗4*e
  23  br  re*e
#03#29*e
   1  dt  26,0✗2,26✗40,0✗The answer is the*e
   2  dt  28,0✗2,28✗40,0✗second one.*e
   3  pa  50*e
   4  br  re*e
   5  pr  *e
   6  ad  l✗cl*e
   7  de  0✗32*e
   8  dt  0,0✗2,0✗40,0✗Conclusions*e
   9  dl  2,0✗11*e
  10  dt  3,5✗2,3✗40,0✗Type the word(retains, loses)*e
  11  dt  5,0✗2,5✗40,0✗which best fits.*e
  12  dt  8,2✗2,8✗40,0✗If a magnet is cut into many smaller*e
  13  dt  10,0✗2,10✗40,0✗pieces, each segment        its*e
  14  dt  13,0✗2,13✗40,0✗magnetism.*e
  15  dl  12,21✗7*e
  16  dt  15,3✗2,15✗40,0✗If a molecule is the smallest segment*e
  17  dt  17,0✗2,17✗40,0✗of a magnet, perhaps it too*e
  18  dl  19,29✗7*e
  19  dt  20,0✗2,20✗40,0✗its magnetism.*e
  20  no  this is a keyboard response sequence.✗*e

qu
 type control word
```

```
ty #03#29-20>53
  20 no  this is a keyboard response sequence./*e
  21 ld  0/c4*e
  22 epi 10,21/2,10/7,21/300/7/k10*e
  23 ld  k10/b2*e
  24 nx  *e
  25 br  re*e
#01#30*e
   1 ca  retains/kl*e
   2 dt  26,0/2,26/40,0/Good. Now continue with the*e
   3 dt  28,0/2,28/40,0/next blank.*e
   4 pa  50*e
   5 br  prl/c4/ge/l*e
   6 ad  l/c2*e
   7 un  uu*e
   8 br  #02#30/c4/ge/3*e
   9 dt  26,0/2,26/40,0/Not quite. Check your spelling and*e
  10 dt  28,0/2,28/40,0/try again.*e
  11 pa  50*e
  12 de  26/4*e
  13 ad  l/c4*e
  14 ad  l/c3*e
  15 br  re*e
#02#30*e
   1 dt  26,0/2,26/40,0/The answer is retains. Type*e
   2 dt  28,0/2,28/40,0/it in so you can continue.*e
   3 pa  50*e
   4 br  re*e
   5 pr  *e
   6 ad  l/cl*e
   7 no  this is a keyboard response sequence./*e
   8 ld  0/c4*e
   9 epi 17,29/2,17/7,29/300/7/k11*e
  10 ld  k11/b2*e
  11 nx  *e
  12 br  re*e
#01#31*e
   1 ca  retains/kl*e
   2 dt  26,0/2,26/40,0/Good. Now copy the conclusions*e
   3 dt  28,0/2,28/40,0/into your notes under experiment 8.*e
   4 pa  50*e
   5 br  prl/c4/ge/l*e
   6 ad  l/c2*e
   7 un  uu*e
   8 br  #02#31/c4/ge/3*e
   9 dt  26,0/2,26/40,0/Not quite. Check your spelling and*e
  10 dt  28,0/2,28/40,0/try again.*e
  11 pa  50*e
  12 de  26/4*e
  13 ad  l/c4*e
  14 ad  l/c3*e
  15 br  re*e
#02#31*e
qu
 type control word
```

```
ty #02#31>55
#02#31*e
   1  dt   26,0/2,26/40,0/The answer is retains. Type it in so*e
   2  dt   28,0/2,28/40,0/you can continue.*e
   3  pa   50*e
   4  br   re*e
   5  prr  *e
   6  ad   1/cl*e
   7  no   macro dua007 april 68 tells student to press space bar to
, this allows time to read text/*e
#01#32*e
   1  dt   30,4/2,30/40,0/--PRESS SPACE BAR TO CONTINUE--*e
   2  epi  30,1/2,30/1,39/9999/1/zz*e
   3  de   30/2*e
   4  de   0/32*e
   5  dt   0,3/2,0/40,0/Observe on page 139 how*e
   6  dt   2,0/2,2/40,0/molecules are believed to line up in*e
   7  dt   4,0/2,4/40,0/magnetized steel. Thus it does not*e
   8  dt   6,0/2,6/40,0/matter where a magnet is cut, there*e
   9  dt   8,0/2,8/40,0/always will be a N and a S pole*e
  10  dt   10,0/2,10/40,0/for the segment.*e
  11  no   macro dua007 april 68 tells student to press space bar to
, this allows time to read text/*e
#01#33*e
   1  dt   30,4/2,30/40,0/--PRESS SPACE BAR TO CONTINUE--*e
   2  epi  30,1/2,30/1,39/9999/1/zz*e
   3  de   30/2*e
al4*e
   1  de   0/32*e
   2  dt   0,0/2,0/40,0/Experiment 9*e

of  you have been signed off
```

EDUCATOR

1. The program is intended to teach elementary concepts of magnetism, static and current electricity to both boys and girls of a Junior High School.

2. The topics dealt with in the program include:

   a) The need for magnets.

   b) Characteristics and types of permanent magnets.

   c) The molecular theory of magnetism

   d) The earth as a magnet and magnetic declination.

   e) Sources of static electricity and its characteristics.

   f) The pith ball electroscope and its use to identify charges.

   g) Conductors, insulators, lightning and thunder.

   h) The relation between magnetism and electricity.

   j) Conditions for generating electricity

   k) Electromagnets and their polarity.

   l) Producing electricity chemically

   m) The dry cell and storage battery.

3. Course material was from the grade eight science text entitled: Science Activities 2 by Hunt, Andrews and Hedges. The 1962 Alberta Department of Science Curriculum was the basis for materials selected from the text.

4. The program is intended for male and female students ages 13 to 15 years who are in grade eight of a Junior High School.

5. Students require from 4 to 8½ hours with an average time of 7 hours to complete the course.

6. The course material is presented via experiments in which the student is instructed to use the equipment located in the drawer of each station desk.

The observations are presented in multiple choice form with the light pen used to select the best observation. Wrong answers are often answered by instructions to try the experiment again or cues to the correct choice.

Conclusions are presented in statement form with blank words to be typed in. Since spelling is assumed to be a major source of error, the message "Not quite. Check your spelling and try again" is displayed when a wrong answer is received. After three tries, the correct answer is displayed, and the student is asked to type in the correct answer. He must type in the correct answer, or he is repeatedly told the correct answer until he does so. Only then is the student permitted to try the next blank.

7. No use is made of either the film projector or the audio attachment, but Dr. Hunka has a series of slides intended for the course. Because of processing problems, they were not ready in time for the course presentation. The course is assumed to have pictorial materials shown to the student, and this is why the text, Science Activities 2 is necessary for each student. When the slides are processed satisfactorily, the text may be eliminated.

8. The light pen is used for the selection of an observation after the student has presumably performed the experiment. The conclusions to each experiment require blanks to be typed in. Students are directed to copy the conclusions into their notebooks when the last blank has been completed correctly. The purpose is to provide a record of the experiments performed when the student returns to the classroom. The summary sheets also distributed at the end of each section require checking by a teacher for accuracy, then they are returned to the students for their records and review.

9. The student does not have to know any special operating techniques other than how to use the light pen and type in a word.

10. The program itself is self-contained and self-operating if the equipment required is available at each station. The teacher need not be in attendance. Summary sheets are given out by the proctor and returned to the proctor for future checking by the teacher.

11. Performance recordings have been made while the course was executed for 24 students. A record of every wrong answer, counters one to four, and times of signing on and off, is available from Dr. Hunka. Other evaluative information is available from Dr. Hunka who has a copy of the author's thesis dealing with this program.

12. In its present state, each student requires the grade eight text Science Activities 2 by Hunt, Andrews and Hedges, along with the equipment listed on page 3 of the Programmer Documentation.

13. Author and programmer: Ken Brown

Documentation completed,
18 Feb 69.

SUMMARY SHEET NO. 1

Write a suitable word in the blanks based on your results.

1. A magnet attracts pieces of ______ and ________.
   If suspended, the N pole swings around to point to the __________ direction.
2. The poles of a bar magnet are located at the _____ of the magnet.
3. A longer name for the N pole of a magnet is the __________ pole.
4. _______ poles attract and _______ poles repell. This is the law of magnetic attraction and repulsion.
5. To find the poles of an unmarked magnet, approach the N pole of a compass. If the compass needle swings away, the end of the unmarked magnet is a _____pole. If the compass needle is attracted, then the end of the unmarked magnet is a ______ pole.
6. The strongest permanent magnets are called ______ magnets.
7. Name four non-magnetic substances. 1.________ 2.________
   3.________ 4.________
8. Magnetic ________ is used to prevent magnetic forces influencing radio tubes or phonograph pick-up arms. The best materials for this purpose are those having ______________ properties.

SUMMARY SHEET NO. 2

1. Each molecule behaves like a tiny _________.
2. Stroking iron filings in a test-tube ______ up these little magnets with their _____ poles pointing towards one end and their ______ poles pointing towards the other end.

3. Shaking or intense jarring of a magnet results in a _____ of magnetism because the __________ become disarranged.

4. If heating a magnetized nail red hot causes the molecules to vibrate farther apart and perhaps rotate, the magnetism should _________.

PLEASE RETURN THE SHEET TO THE PROCTOR AND THEN CONTINUE AT YOUR STATION.

SUMMARY SHEET NO. 3

1. A negative static charge is produced using fur and a(n) ____________ rod.

2. A positive static charge is produced using a ______ _______ and a _________ rod.

3. The law of electrical attraction and repulsion states that _________ charges repel and _______ charges _________.

4. A suspended pith ball is charged. On being approached with a charged plastic rod, the ball is repelled from it. The ball has a ______ charge on it. If the ball was attracted to the charged rod, the ball may have been ____________ charged or ___________.

   (a neutral ball is attracted to both types of charge)

5. Two examples of electrical conductors are ___________ and ____________.

   Two examples of electrical insulators are ___________ and ____________.

6. Lighting rods protect a building by

   a. allowing __________ to escape from the earth which promote cloud neutralization.

   b. providing a safe path for lightning to the _________.

SUMMARY SHEET NO. 4

1. A compass needle is deflected by a wire carrying an ________ ________.

2. The essential parts of an electromagnet are a ________ of insulated wire and an ________ core.

3. The strength of an electromagnet increases when the number of ________ is ________ or the ________ flow is ________.

4. Insulated wire is used in a coil so the ________ will go along the path of the coils rather than jump from one ________ to the other.

5. The principle of an electric bell is an interruption of the ________ flow through two ________. A ________ returns the armature to the ________ ________ which then allow the magnets to become energized again.

SUMMARY SHEET NO. 5

1. The sounder of a telegraph set consists of an ________ and an ________ which moves up and down in response to the ________ of the sender.

2. The telephone was invented by ________ ________ ________.

3. The diaphragm of the telephone transmitter serves to change the ________ waves striking it into tiny vibrations which vary the ________ flow through ________ granules.

4. The essential parts of a telephone receiver are an ________ and a ________.

5. In a telegraph, the electromagnet causes the ________ to move while in a telephone it causes the ________ to move.

PROGRAMMER

1. The course assumes each student will perform each experiment as described by the CRT. The responses of the student are recorded and analyzed by two macros, one for light-pen responses and the other for keyboard responses. The course flow moves from consecutive experiments until a section has been completed. (Part 1-Magnetism, Part 2- Static electricity,Part 3-Current Electricity). Then the student is given a choice whether to review the materials just completed or continue with the next part.

2. MAGEL uses 3 macros:

a) DUA007- Rather than an indefinite pause, this macro allows the system to continue for other students. It also displays the message:"Press space bar to continue." on rows 29 and 30.
Calling format: CM DUA007

b) KBA029- This macro anaylzes light pen responses, providing feedback on the adequacy of the response, and after 3 wrong answers, displays the correct answer for the student. i.e. "Point to the first answer now." Counters one to four record correct answers total, correct answer first try total, wrong answer total, and wrong answer total for each question respectively. If the light pen signal received is not from the three designated targets, the message, "Point to the response square please." is displayed.
Calling format: CM KBA029⁊PEN5¬,2,4,2,10¬,RIGHT. NOW CONTINUE¬, WITH THE CONCLUSIONS.¬,2,8,2,10¬,NO. CHECK THE POLARITY¬, AND TRY AGAIN.¬,THE ANSWER IS THE SECOND ONE.¬,POINT TO IT NOW AND CONTINUE.□

C) KCA029- This macro analyzes keyboard responses, providing feedback on the adequacy of the response. After 3 wrong answers, the correct answer is displayed . Counters one to four record the same responses as in macro KBA029. Since the majority of wrong answers would be of a spelling nature, the message is displayed:"Not quite. Check your spelling and try again." when a wrong answer is received.

Calling format: CM KCA0297 3,5¬,6 ,5¬,6¬,k21¬,MAGNET¬, CORRECT. NOW COPY THE CONCLUSIONS¬, INTO YOUR NOTEBOOK.¬, THE ANSWER IS MAGNET. TYPE IT¬, IN NOW AND CONTINUE. ◻

3. Buffer 1 is used to record the response number. This enables a student's progress to be determined anytime after starting the course. No other buffers are used.

4. Counters used are:

C1- correct answers total

C2- " " " first try.

C3- wrong answers total

C4- " " " for each question.

When C4 is equal to or greater than 3, the student is branched to a message telling him the correct answer. Any further errors repeat the message again until the student types or points to the correct response.

5. No switches are used by the course.

6. No return registers are used.

7. No functions are called.

8. There are no proctor messages.

9. A response time has been specified for every EP. No system latency time-setting is necessary.

10. Dummy EP's use the ZZ identifier.

11. Only the standard dictionary is used. There are no graphic sets required.

12. There are no film reels required, but each student must have the text: Science Activities 2 by Hunt, Andrews and Hedges. Page references are made in the course where there are illustrations or ancilliary information.

13. The following list of equipment is necessary for <u>each student</u> to perform the experiments specified in the course:

2-bar magnets

1-horseshoe magnet

One small piece of wood, chalk, rubber, tacks, pennies, iron, glass.

1- magnet carrier

1-compass needle

1- iron bar, round or square about 5 inches long.

3- 3 inch finishing nails, one filed in the middle so it can be broken into two pieces easily.

1-2 inch by 2 inch sheet of copper, aluminum, glass, wood, iron.

1-test tube (standard size) with 1 inch of iron filings, sealed by a rubber stopper.

2- sheets of standard size paper.

2-lucite plastic rods along with a sheet of polyethylene.

2-ebonite rods along with a cat's fur

1-support hanger and retort stand to support a magnet or ebonite rod.

1- pith ball with thread through it to attach it to the retort stand.

2-dry cells

2-ft of insulated copper wire (Low voltage)

1-air coil with sufficient windings to show deflection of a galvanometer using a bar magnet.

1-push button.

6-large tacks

1- galvanometer

1- voltaic wet-cell

SUMMARY OF OPERATOR'S INSTRUCTIONS

1. Course name and segments: MAGEL - 000.
2. Dictionary/graphic sets required: none other than the standard dictionary.
3. Functions called: none
4. Macros called: DUA007, KBA029, KCA029
5. Film reels required: none
6. Audio tapes required: none
10. Student sign-on command: on magel/stn
11. Summary sheets must be handed out by the Proctor.
13. Performance recordings are necessary.

OPERATOR

1. MAGEL (Magnetism and Electricity) consists of one long segment:

   MAGEL- 000: Introduction, text specified which is required by a student to move through the program.

2. No dictionaries other than the standard one, are required.

   No graphics are required.

3. No functions are called.

4. MAGEL calls 3 macros:

   DUA007 - Uses a dummy ep for a pause by the student to read text or perform an experiment. Displays "PRESS SPACE BAR TO CONTINUE" on the last two lines of the screen.

   KBA029 - A light pen response sequence which allows three wrong answers to be selected, then the answer is given the student. Counters record whether the answer is correct on the first try or whether the answer requires more than a single try.

   KCA029 - A keyboard response sequence which allows three wrong answers to be typed in before giving the correct answer. Counters record whether the answer is correct on the first or subsequent tries.

5. MAGEL does not presently use the film projector- no film reels are required. Slides have been made however but because of difficulties of processing onto the film reel, they are not available.

6. MAGEL does not use audio attachments- no audio tapes required.

7. MAGEL requires between eight and nine hours for complete course

execution depending on the ability of the student.

8. Response times are specified for each ep- no need to set an overall response time.
9. An introductory program is required such as on the demo pack to show students how to operate the terminal before starting the course.
10. Students sign -on to segment 000 to execute the entire program, i.e.: on magel/stn
11. A teacher does not need to be in attendance during execution of the program, but a Proctor must be available to hand out review sheets which require completion then are returned to the Proctor for marking by a teacher.
12. There are no Proctor messages in the program.
13. Performance recording is necessary to retain a record of counters and wrong answers which students may supply.
14. The program is intended for grade eight students in the Alberta Junior High School system. The science curriculum is the guide for the course.

APPENDIX 3

TEST BLUEPRINT

<u>TEST BLUEPRINT</u>

GRADE EIGHT SCIENCE
ELECTRICITY AND MAGNETISM

I. MAGNETISM

Objectives / Course Content	Knowledge	Comprehension	Application	Analysis	Evaluation
Natural Magnets	Terms: Lodestone, Magnetite Item # 5	Understand principle behind crude compass Item # 1			
Properties of Magnets	Know concepts Poles, properties Item # 6				
Magnetic substances	Know which substances are magnetic and how to find it out Item #2				
Magnetic Force	This will be examined in detail in section III.				
Making magnets	Terms: Temporary, Permanent, Inductive, Alnico Item #3	Ability to translate relationship expressed diagrammatically Item #12			
Law of Magnetic Attraction and Repulsion		Ability to distinguish warranted or contradicted conclusions based on this law Item #13	Ability to apply the law to new situations Item # 15		

Objectives / Course Content	Knowledge	Comprehension	Application	Analysis	Evaluation
Test for Magnetism	Recall the test Item # 8				
Nature of Magnetism	Know concept of molecular magnets Item #7, #9	Understands conditions under which destruction of magnetism occurs Item # 14			
Magnetic Lines of Force	Knows where force of magnet is greatest Item # 10	Understands magnetic lines of force well enough to distinguish incorrect diagrams Item #4			
Earth as a Magnet	Terms: Dipping needle Magnetic Declination Item #11			Ability to distinguish relevant from irrelevant information as well as cause and effect relationships Item # 45, #47	

Total number of items 17

Knowledge 18% Comprehension 10% Application 2% Analysis 4 %

I. Magnetism 34%

II. STATIC ELECTRICITY

Objectives Course Content	Knowledge	Comprehension	Application	Analysis	Evaluation
Production of static electricity	Know how to produce it and under what conditions it is most evident Item #17	Understand that difference in atmosphere may affect results of experiment using static electricity Item #16		Able to distinguish cause and effect relationships and to separate relevant from irrelevant information. Item #28, #29 #30, #31	
Nature of electricity	Know basic terms and facts: molecule atom neutron proton electron Two kinds of charges and how to detect and identify them electroscope Item #18	Understand what current of electricity is Understand effect of substances on charged objects Item #22	Able to apply law of electrical charges in novel situation Item #26		
Electrical conductors and insulators	Terms: Item #19, #20				

Objectives Course Content	Knowledge	Comprehension	Application	Analysis	Evaluation
Lightening and Thunder		Understand the formula used to determine how far away flash is Item #21 Understand the principle behind use of lightening rods Item #23			Using the criteria they have assembled of a scientific approach evaluate common ideas concerning lightening and thunder Item #27
Control of static electricity		Understand the nature of static electricity well enough to know how to prevent accidents Item #24, #25			

Total number of items 16

Knowledge 8% Comprehension 12% Application 2% Analysis 8% Evaluation 2% 32%

III. MAGNETISM AND ELECTRICITY

Objectives Course Content	Knowledge	Comprehension	Application	Analysis	Evaluation
Relationship between Magnetism and Electrcity	Know use of electroscope compass galvanometer generator Item # 32	By determining the results of a given experiment show understanding of relationship between magnetism and electrcity Item #40			
	Know that magnetic field surrounds a conductor Item #33				
Electromagnets	Know what an electromagnet is and how to determine its strength Item #34	Show understanding of what an electromagnet is Item #44			
Uses of Electromagnets	Know how common instruments (telegraph telephone, electric bell) make use of electromagnets Item #35, #36, #37				
		Can explain why an electric bell rings Item # 43	In a new situation apply their knowledge of left hand rule Item #41		

Objectives Course Content	Knowledge	Comprehension	Application	Analysis	Evaluation
Electricity in Motion	Know common cell ingredients Item # 39 Know how to care for cell Item #38 Terms: Circuit broken closed open complete Item #42				
Electricity and Magnetism	Basic Facts and Understandings examined in higher process questions			Can identify given elements regarding static electricity and magnetism and then distinguish major relationships Item # 46, # 48, # 49, # 50	
Total number of items 17	Knowledge 18%	Comprehension 6%	Application 2%	Analysis 8%	Total 34%
TOTALS	KNOWLEDGE 44%	COMPREHENSION 28%	APPLICATION 6%	ANALYSIS 20%	EVALUATION 2% TOTAL 100%

MANUAL FOR TEST ON MAGNETISM AND ELECTRICITY -GRADE 8 SCIENCE

Nature of the test:

The content of the exam is derived from chapters three and four of Science Activities Book Two by Hunt, Andrews and Hedges . This prescribed text for grade eight science is used in Alberta schools. However, it is hoped that the exam contains material basic enough to be useful in any introductory unit on magnetism and electricity at the grade eight level.

Directions For Administering:

The time limit for this fifty multiple choice exam is forty-five minutes. The administrator of the exam should make certain that each student is provided with an answer sheet , a pencil and a test booklet. After the students are seated and have filled in their name, class and date, the administrator should read over the directions to the students as each pupil follows. The sample questions are read, and it is noted where the answer has been blackened in. Any questions which the students may have should be answered at this point. As the pupils are writing the exam, the administrator should walk around to the desks and make certain that the answers are being entered in the proper manner. One may advise when half time has gone, and when five minutes are left.

When the time is up, the administrator should indicate that everyone must stop writing. He should then have the students pile the answer sheets and test booklets in two separate piles at the front of the room. If the administrator wishes to make any comments relevant to the exam at this point, he may note them and include the comments with the answer sheets. The scored answer sheets will be returned to the administrator as soon as possible.

INSTRUCTIONS TO THE STUDENT

This is a forty-five minute test. It contains fifty questions. Choose the best answer to each question. Mark all your answers on the separate answer sheet provided. Do not make any marks on the test booklet. Make certain that your name is on the answer sheet. Start and stop when indicated by your instructor. Do not spend too much time on any one question. If you finish early, go back and check your answers. Make certain that you have only one answer marked for each question. If your erase an answer, erase it completely.

Your score is the number of correct answers you mark. There is no penalty for guessing.

There are two types of questions on the test.

1) the typical multiple choice question:

Example

Of the following which is a conductor of electricity?

a. glass

b. copper

c. plastic

d. rubber

On the answer sheet, the space under "b" has been blackened.

example a b c d

2) a matching type of question:

Example

Tell whether each of the statements following the fact is

a. a cause of the fact

b. a result of the fact

c. not related to the fact

Fact: a flash of lightning occurs.

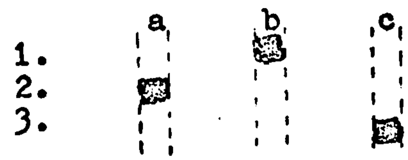
Statements

1. a roar of thunder can be heard

2. Electricity passed between clouds and the earth

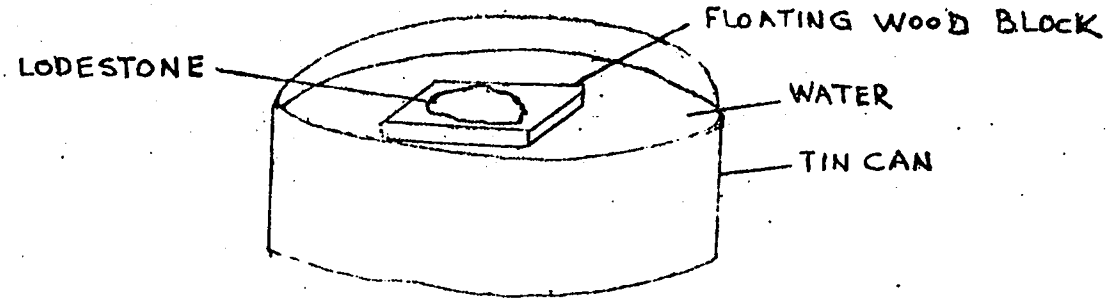
3. It is dangerous to stand under a tree during a rainstorm.

On the answer sheet, the following spaces have been blackened:



Mark all your answers on the answer sheet by filling in the space under the correct letter with a pencil.

1.



The above diagram illustrates a principle used in

a. an instrument used for measuring depth

b. a device for determining direction

c. a bar magnet

d. an electromagnet

In questions 2 and 3, which of the group does not belong?

2. a. stainless steel

b. cobalt

c. alnico

d. silver

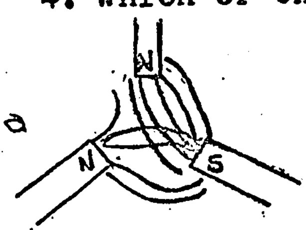
3. a. aluminum

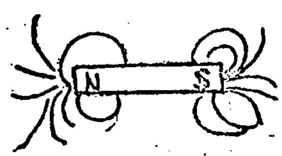
b. lead

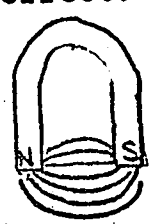
c. nickel

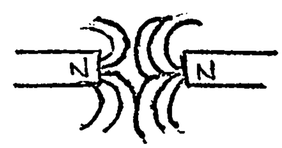
d. cobalt

4. Which of the following diagrams is incorrect?

a 

b. 

c. 

d 

5. The attraction between Magnés iron-tipped crook and a strange rock called magnetite is shown by

a. a positively charged cloud and a negatively charged cloud.

b. man and the earth.

c. a magnetized hammer and a tack.

d. an iron fence post and the earth.

6. The pole of any magnet is best defined as

a. the end of a magnet.

b. the strongest part of a magnet.

c. the axis of the earth.

d. the part of the magnet that attracts or repels.

7. Which of the following would make the strongest magnet?

a. iron

b. magnetite

c.steel

d. alnico

8. You can tell that a piece of iron is magnetized by presenting one end of it and then the other to the north pole of a known magnet if

a. the first end of the iron is attracted to the magnet.

b. both ends of the iron are attracted to the magnet.

c. one of the ends of the iron is repelled by the magnet.

d. both ends of the piece of iron are repelled by the magnet.

9. When an iron nail is held near one pole of a magnet which of the following is most likely to result ?

a. the nail will not become magnetized because it doesn't touch the magnet.

b.the molecules of the magnet lose some magnetism to the nail and are demagnetized.

c. the nail becomes magnetized because its molecules are patterned regularly by the magnetic force of the magnet.

d. the nail is magnetized because the magnet loses some magnetism through induction.

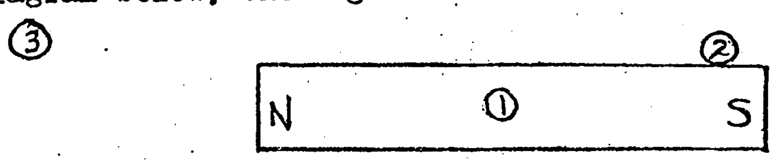
10. In the diagram below, the magnetic force is greatest at

a. point 1.

b. point 2.

c. point 3.

d. no special point as it is even.



11. Magnetic declination depends upon

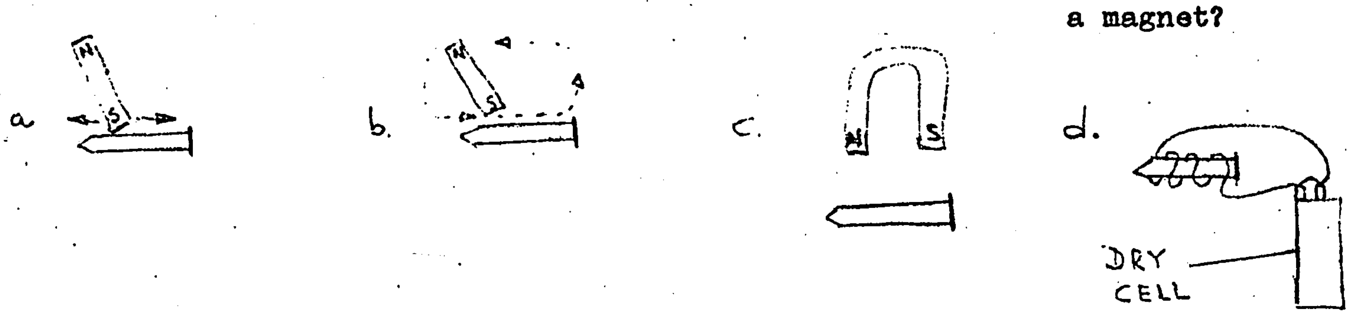
a. the position you occupy in relation to magnetic north.

b. the distance to the north magnetic pole.

c. the position of the earth as it rotates.

d. the degrees of latitude.

12. Which of the following diagrams illustrates the best way to make a magnet?



13.If a dipping needle is passed over the north magnetic pole, the south seeking pole of the needle will

a. point up.

b.point down

c. spin around.

d. not move.

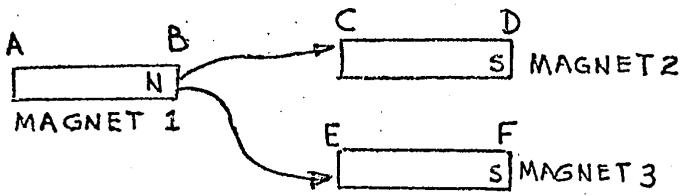
14. In an experiment, one end of a test tube containing iron filings repels the north pole of a good compass. However in a second experiment the same end of the test tube will not repel the north pole of a compass. Under which of the following conditions would you account for this?

a. Someone had dropped the test tube.

b. The test tube had been heated.

c. The compass needle had been jarred.

d. only former answers a. and b.

15. 

End B of magnet 1 was stroked on magnet 2 from C to D and on magnet 3 from E to F.

Find a true statement.

a. d will attract e.

b. b will attract e.

c. d will repell b.

d. f will repell c.

16. In an experiment, Harold rubbed a glass rod with silk and the rod made the leaves of a gold-leaf electroscope repell each other. On the following day, John repeated the experiment with the same results. However, when Harold attempted the experiment again a week later, he was unable to move the leaves of the electroscope. Which of the following explanations offers the best reason for his failure?

a. John had probably removed the neutrons and protons from the silk and the glass rod.

b. On the first day, the air was cold and dry. A week later, it was warm and moist.

c. The boys had probably supercharged the electroscope thus making it defective.

d. Harold probably was wearing rubber soled shoes the first time and the last time he wore leather soled shoes and was therefore grounded.

17. Which of the following statements is true of static electricity?

a. It is determined by the strength of the current.

b. It is always a useful form of electricity.

c. It results in a decrease in friction.

d. It varies depending on the moisture in the air.

18. An uncharged comb would have

a. a shortage of electrons.

b. a surplus of protons.

c. a surplus of electrons and neutrons.

d. an equal number of electrons and protons.

19. Because electricity will not travel through certain substances, we can have

a. heating elements.

b. windows.

c. lightning rods.

d. bare wire on power lines.

20. Which of the following is true of a conductor?

a. Protons flow through it with great difficulty.

b. Electrons will not flow through a magnetic conductor.

c. Electrons flow through this substance with relative ease.

d. If the electrons are able to flow through the conductor, they must be repelled by the protons.

21. To calculate how far away a flash of lightning is, you need to know all of the following except

a. length of time between the flash and the clap of thunder.

b. the loudness of the thunder.

c. the speed of sound.

d. whether sound or light travels faster.

22. A pithball electroscope has a negative charge. It is touched with the blade of a steel knife, then with a rod having a shortage of electrons. Now the electroscope has

a. a surplus of protons.

b. a negative charge.

c. a shortage of electrons.

d. a surplus of electrons.

23. Whichof the following is the best scientific reason for the use of lightning rods?

a. The rods will make certain that lightning does not strike your house.

b. The rods gradually receive electrical charges and discharge them into the earth.

c. The copper rods repel the charged clouds.

d. The protons that the rods send out attract the clouds and make them discharge.

24. When people clean clothes with gasoline, accidents are often caused because

a. friction produces static electricity which ignites the gas.

b. rubbing produces heat which ignites the gas.

c. rubbing pushes the gas molecules together causing a small nuclear explosion.

d. the gasoline is highly combustible.

25. Under which of the following conditions would the driver of a gasoline truck be safest?

a. A cold dry winter day with a chain dragging from the frame of the truck to the ground.

b. A cold dry winter day with a chain dragging from the frame almost to the ground.

c. A hot wet summer day with a chain dragging from the frame of the truck to the ground.

d. A hot wet summer day.

26. A,B,C, and D are charged pith balls. A has a positive charge, B has a negative charge, C has a charge opposite to A and D attracts C. Find a true statement.

a. C will attract B.

b. C will repel A.

c. D will attract B.

d. D will attract A.

27. Bob, Bill, Tom and Harry were outside in an electrical storm. Which of their statements best illustrates a scientific background and attitude?

a. Bob said that they should stand under an object taller than themselves so the lightning would strike the taller object and not them.

b. Tom said that he was afraid of lightning and they should do something immediately.

c. Bill said that they should not seek shelter but they should not run because they might produce static electricity.

d. Harry said that once they had heard the thunder, they were safe from that particular thunderbolt.

In questions 28 to 31 tell whether each of the statements following the fact is

a. a cause of the fact.

b. a result of the fact.

c. not related to the fact.

Fact : Static electricity can be built up on a non-conductor.

Statements:

28. Jim walked across the rug and got a shock when he touched the fountain.

29. When he got to the fountain, Jim saw a spark and heard a snap.

30. The shock upset Jim so much that the water didn't taste good.

31. When Jim was walking he was sliding his feet.

32. To test something to see if it was producing an electric current, one could use

a. an electroscope.

b. a compass.

c. a generator.

d. two pithballs.

33. An electric current flowing through insulated copper wire causes deflection in a compass needle. This shows that

a. the wire has a magnetic field surrounding it.

b. the insulation is faulty.

c. The wire is magnetized and the compass is attracting it.

d. the compass has become an electromagnet.

34. The strength of an electromagnet depends upon

a. the strength of the current.

b. the number of turns of wire.

c. the number of turns of wire and the current strength.

d. the strength of the current, the size of the core and the number of turns of wire.

35. The principle on which a telephone transmitter works is

a. a metal diaphragm will attract to an electromagnet.

b. the size of current varies with the density of the material through which it passes.

c. an electric current causes many voice currents in a copper wire.

d. that pushing carbon granules together produces electricity.

36. In an electric bell the circuit is rapidly opened and closed at the

a. contact point.

b. switch.

c. spring.

d. gong.

37. The change of energies in a telephone can best be described as

a. sound,varying electric current,varying electromagnet, sound.

b. sound, varying electric current, sound.

c. sound, varying electromagnet,varying electric current,sound.

d. sound, varying electric current,sound,varying electromagnet.

38. One of the main reasons for using a dry cell in a flashlight is

a. it produces current electricity.

b. there is no liquid in it.

c. it will not produce current unless there is an unbroken path, by which it can return to the cell again.

d. it may be connected in parallel or in series.

39. One of the following could not be used to make a cell:

a. zinc, dilute sulphuric acid, copper.

b. copper, lemon, zinc.

c. potassium hydroxide, mercuric oxide, dilute sulphuric acid.

d. carbon, zinc, moist sal ammoniac.

40. A magnet is thrust through a coil of wire and a galvanometer needle deflects. This demonstrates that

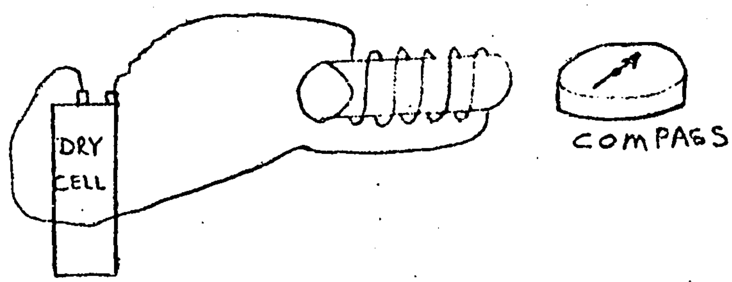
a. a flow of electricity causes magnetism.

b. magnetism can cause a flow of electricity.

c. this is the principle on which an electric motor operates.

d. this is the principle on which an electromagnet operates.

41.



For the above apparatus,

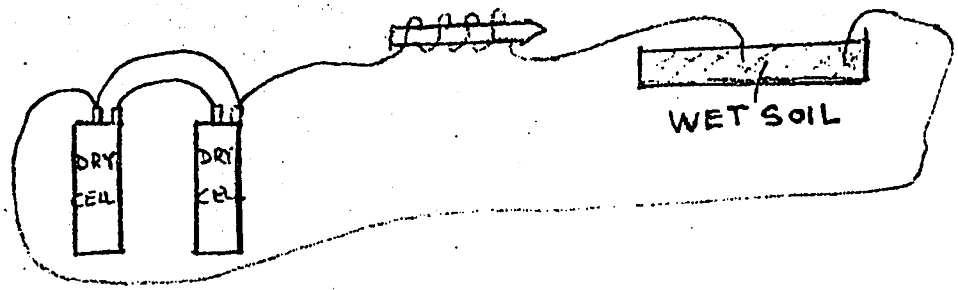
a. the S pole of the compass will repell the coil.

b. the S pole of the compass will attract the coil.

c. both the S pole and the N pole would repell the coil evenly.

d. the coil would have no effect on the compass.

42.



The apparatus above would not be effective because

a. the circuit is grounded.

b. the circuit is broken.

c. the dry cells are connected in parallel and there are only two of them.

d. the dry cells are not properly connected.

43. An electric bell rings because

a. the armature breaks the circuit at the contact point.

b. the electromagnet attracts the hammer.

c. the screw pushes the armature towards the gong.

d. the electromagnet attracts the armature.

44. An electromagnet must be wound with insulated rather than bare copper wire because

a. the insulated wire prevents the magnet from losing strength.

b. only insulated wire could carry strong enough current.

c. the insulated wire keeps the current in a predetermined area.

d. the wire might melt if it were not insulated.

In questions 45 to 50 pick out one of the reasons to explain each of the given situations.

<u>Reasons</u>

a. due to the rules of magnetic shielding

b. due to the earth's magnetism

c. due to static electricity

d. due to the weight and thickness of the substance

45. A compass needle does not always point straight north even in an open field.

46. Tacks are not attracted to a sheet of iron surrounding a powerful electromagnet.

47. A compass needle swings and comes to rest.

48. A magnet will attract tacks when a sheet of aluminum is placed around it.

49. A compass in an aeroplane is not attracted to the metal parts of the interior.

50. Pieces of paper are attracted to the plastic around the magnet.

Scoring Key   Pre- and First Posttest (Appendix 4)

Question	Answer	Question	Answer
1	b	26	c
2	d	27	d
3	b	28	b
4	b	29	b
5	c	30	c
6	b	31	a
7	d	32	b
8	c	33	a
9	c	34	c
10	b	35	b
11	b	36	a
12	b	37	a
13	a	38	b
14	d	39	c
15	a	40	b
16	b	41	b
17	d	42	d
18	d	43	d
19	d	44	c
20	c	45	b
21	b	46	a
22	c	47	b
23	b	48	a
24	a	49	a
25	c	50	c

APPENDIX 5

GRADE VIII SCIENCE

Electricity and Magnetism

Directions:

DO NOT MARK THIS BOOKLET!

Choose the BEST answer to each question and darken the appropriate space on the answer sheet next to the number of that question.

There are 50 questions and each has a value of one mark.

Use a pencil to mark your answer, erase incorrect answers carefully.

Time Limit is 40 minutes.

1. A transformer with fewer turns on the secondary will cause voltage to

   A. decrease
   B. increase
   C. remain the same
   D. blow a fuse

2. The wire in a lamp filament heats and emits light because the wire

   A. is magnetic
   B. is incandescent
   C. is thin
   D. has resistance

3. A house meter records the electrical power used in

   A. amperes
   B. watts
   C. watt hours
   D. kilowatt hours

4. The storage battery is charged by having a current flow into the battery. This current, compared to the current that would flow on discharge is

   A. adirect current
   B. greater
   C. in the opposite direction
   D. in the same direction

To show that you understand the principle involved in each of the following paragraphs, choose the right scientific term from the answers provided in each question that describe the situation in that question for questions 5 to 11.

5. Electron beam on a fluorescent screen.

   A. telephone
   B. television
   C. Nichrome element
   D. transformer

6. Tom wanted more power for his experiment, so he changed the wires on the dry cell.

   A. short circuit
   B. dry cells in parallel
   C. closed circuit
   D. dry cells in series

7. Billy received an electric train for Christmas, but he was not able to play with it until the stores opened after the holidays.

A. circuit breaker
, electromagnet
C. transformer
D. voltaic cell

8. At night Joan came to sleep with her mother, she was afraid of the flashes of lightning during the storm.

A. short circuit
B. static electricity
C. solar energy
D. closed circuit

9. Bill lives in Halifax and his grandmother lives in Edmonton. Bill spoke to her by long distance telephone. They talked to each other as if they were in the same room. Yet his grandmother was 3000miles away and sound travels ata speed of 1100 feet per second.

A. alternating current
B. closed circuit
C. varying electric current
D. electromagnet

10. During an electrical storm, when thunder and lightning was extremely severe, Walter pressed the doorbell button at the front door. The bell did not ring.

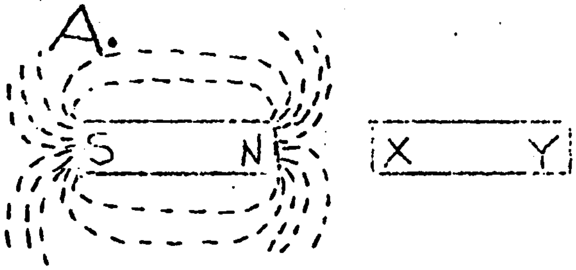
A. static electricity
B. short circuit
C. solar energy
D. alternating current

11. When Anne entered her bedroom at night, she flipped the switch near the door and observed that the room was immediately flooded with light.

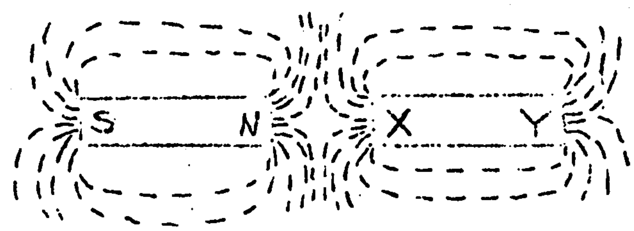
A. voltaic cell
B. transformer
C. closed circuit
D. varying electric current

For questions 12 to 15 inclusive choose one of the following diagrams as the best representation of the lines of force for the objects involved. In each case there is a bar magnet with north and south poles marked N and S respectively. There is also another object with its ends marked "X" and "Y".

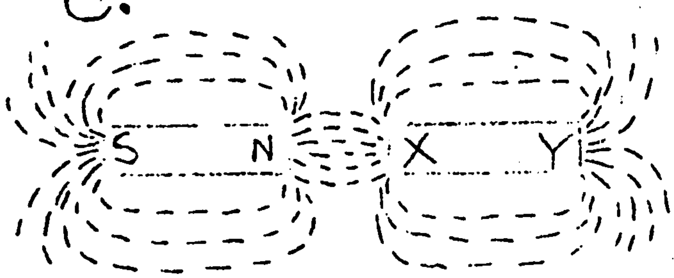
A.



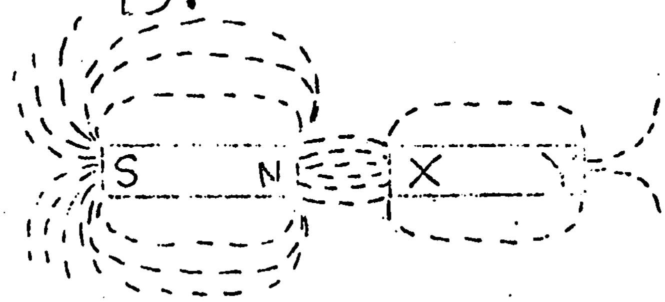
B.



C.



D.



12. Bar XY is a bar magnet where X is the South pole.

13. Bar XY is a bar magnet where X is the North pole.

14. Bar XY is an Iron bar.

15. Bar XY is an ebonite rod.

16. John and Bill were arguing about compasses. John said that compasses in Vancouver, Regina, and Toronto all pointed toward the same place. Bill said they did not. Who was right and why?

    A. Bill, because the geographic north pole and the magnetic north pole are 1100 miles apart.
    B. Bill, because the steel mills at Toronto will deflect the compass needle.
    C. John, because the dark end of the compass needle always points toward the north pole.
    D. John, because the compass needle always points toward the north magnetic pole.

17. A piece of metal may be magnetized by stroking it with one pole of a magnet in the

    A. same direction
    B. opposite direction
    C. lateral direction
    D. north direction

18. Magnetism in a permanent magnet of iron is caused by the

    A. motion of molecules in iron
    B. motion of electrons in atoms
    C. lining up of individual electrons
    D. lining up of individual molecules

19. Which of the following is <u>not</u> a theory of the source of the earth's magnetism?

    A. The earth's rotation may cause its core to become magnetized
    B. The attraction of the moon may line up the molecules of iron in the earth's core.
    C. Sun spots may have caused the earth's magnetic field.
    D. There are electric currents within the earth which may make the core an electromagnet.

20. Chemical energy is transformed into electrical energy in

    A. a generator
    B. an electromagnet
    C. a battery
    D. an electrode

For questions 21 to 23 inclusive refer to the following paragraph.

You are given two strips, A and B., of different types of plastics which have been rubbed with different cloths, and an ebonite rod which is charged negatively.

21. Strip A is attracted to the ebonite. This indicated that Strip A is

    A. positive
    B. negative
    C. neutral
    D. either positive or negative

22. Strip B is repelled from the ebonite. This indicates that Strip B is

    A. positive
    B. negative
    C. neutral
    D. either positive or negative

23. If strips A and B were rubbed with the same cloth, the charges on them would be

    A. positive
    B. negative
    C. alike
    D. determined only by comparing with a known charge

24. Two ways of increasing the strength of an electromagnet are:

    A. increase the current and increase the length of the soft iron core.
    B. increase the number of turns about the core and increase the diameter of the core.
    C. increase the current and use a copper core
    D. increase the number of coils and increase the current

25. The diaphragm of the telephone receiver is vibrated by the

    A. carbon grains
    B. permanent magnet
    C. electromagnet
    D. wires

26. The most desirable property of an electromagnet is that it is

    A. a permanent magnet
    B. iron
    C. a temporary magnet
    D. inexpensive

27. Bell and Edison both did work on one of the following inventions. Which one?

    A. telephone
    B. light bulb
    C. phonograph records
    D. radio

28. Before applying the left hand rule one needs to know the

    A. direction of the electron flow
    B. the number of turns in the coil
    C. the strength of the current
    D. law of magnetic attration and repulsion

29. A substance can be considered to be a magnet only if

    A. it is attracted by another magnet
    B. the double stroke method is used to make it
    C. it is able to repel another magnet
    D. it is able to influence a compass needle

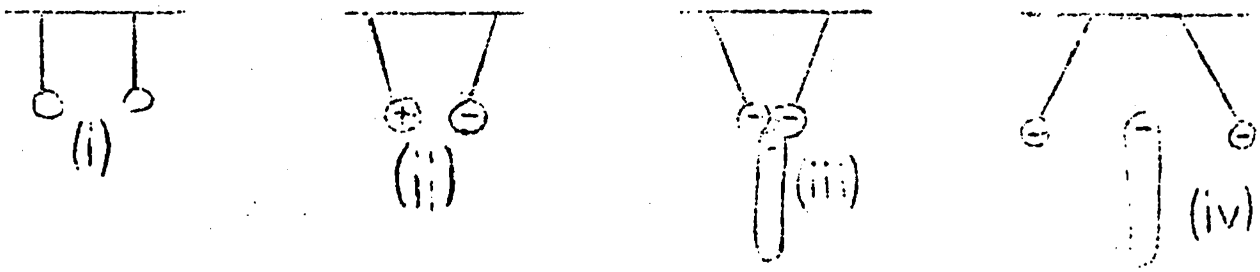
30. The man who described the principle on which the dynamo operates

    A. Edison
    B. Faraday
    C. Volta
    D. Franklin

31. If in a string of lights, one light burns out but the rest remain aglow, this would be an example of

    A. short circuit
    B. a series circuit
    C. alternating current
    D. a parallel circuit

32. Referring to the diagram of the two pith balls below, answer question 32 . (The ebonite rod is negatively charged.)



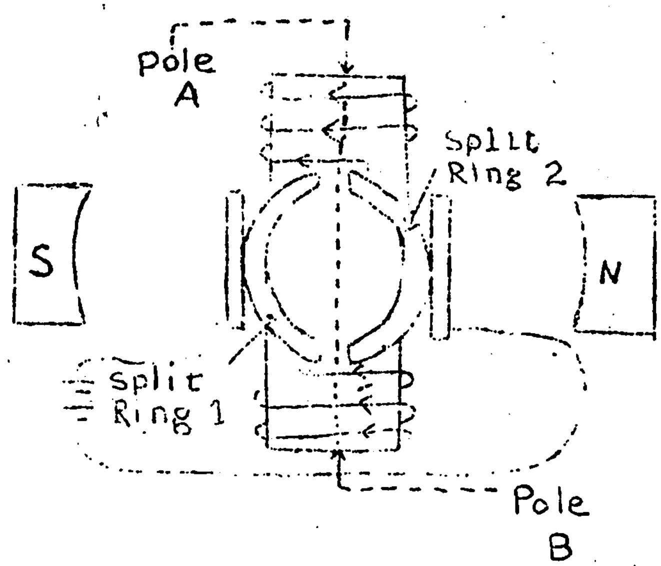
If we touch both pith balls with the ebonite rod what will they then do?

A. They will both hang vertically as in (i)
B. They will be inclined toward one another, as in (ii)
C. They will both be attached to the ebonite rod, as in (iii)
D. They will be inclined away from each other, as in (iv)

33. You would expect to find a "penstock" used in

A. a steam powered generating station
B. hydro electric generating station
C. an atomic electric power station
D. in a plant utilizing solar energy

Questions 34-38, inclusive, refer to the following diagram of an electric motor.



34. When the switch is closed the current flows as indicated by the arrows. This makes the upper pole, A, of the armature a

A. south pole
B. north pole
C. neutral pole
D. permanent magnet

35. When the armature has rotated 90 degrees, the left hand brush touches

A. split ring 1 only
B. split rings 1 and 2
C. pole A
D. split ring 2 only

36. When the armature rotates through another 90 degrees the upper pole is

A. neutral
B. demagnetized
C. south
D. north

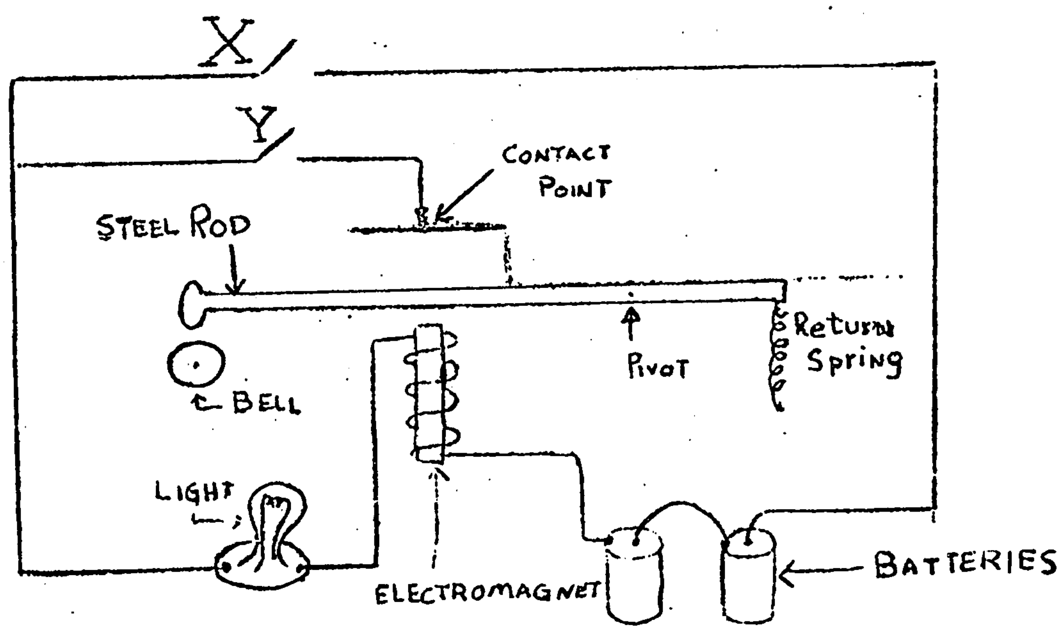
37. By the time the armature has made one complete revolution the current in the armature has changed direction

A. one time
B. two times
C. four times
D. not at all

38. If the current flows in such a direction that the armature rotates <u>clockwise</u> from its position in the diagram, poleB must be

A. a south pole
B. electrically charged
C. a north pole
D. stronger than pole A

The circuit below can be made to operate as several instruments by opening and closing of the switches "X" and "Y".



From the list below choose the best arrangement of the switches that will make the circuits that are described in questions 39-41.

A. X is open, Y is closed
B. X is closed, Y is open
C. X and Y are both closed
D. X and Y are both open

39. a door bell

40. a light that stays on continually

41. a light that blinks off and on

42. Which of the following substances would make a good magnetic shield?

A. plastic
B. water
C. brass
D. steel

43. Experiments with static electricity yield the best results when weather is

A. cold and dry
B. hot and dry
C. cold and damp
D. hot and damp

44. Heating a bar magnet tends to destroy its magnetism because heating causes

A. the molecules to become hot thus causing the magnet to expand
B. the molecules to arrange themselves in an orderly fashion
C. the molecules to arrange themselves in a disorderly fashion
D. the molecules to lose their magnetism

45. Electrical energy is changed into heat energy by

A. an electric motor
B. resistance of a conductor
C. an electric generator
D. a cartridge fuse

46. Which of the following devices does <u>not</u> make extensive use of an electromagnet?

A. television
B. microphone
C. electric fan
D. electron doorbell

47. If a magnet is broken in half the results are

A. destruction of the magnet
B. doubles the strength of the magnet
C. make two magnets out of one
D. has no effect on the original magnet and magnetic field

48. Gases used in light bulbs

A. nitrogen and oxygen
B. oxygen and argon
C. nitrogen and argon
D. nitrogen and hydrogen

49. The most common material used for a compass box is

A. nickel
B. plastic
C. steel
D. wood

50. An electroscope is a device for

A. looking at charged bodies
B. detecting electrical charges
C. using gold leaf
D. suspending charged bodies

Scoring Key Second Posttest (Appendix 5)

Question	Answer	Question	Answer
1	a	26	c
2	d	27	c
3	d	28	a
4	d	29	c
5	b	30	b
6	d	31	d
7	c	32	d
8	b	33	b
9	c	34	b
10	d	35	b
11	c	36	d
12	c	37	b
13	b	38	c
14	d	39	a
15	a	40	b
16	d	41	a
17	d	42	d
18	d	43	a
19	b	44	c
20	c	45	b
21	a	46	b
22	b	47	b
23	d	48	c
24	d	49	b
25	c	50	b

APPENDIX 6

Attitude Pretest

Instructions to the Student

Please read each of the following statements carefully. Blacken in the first column of your answer if you agree with the statement. Blacken in the fifth column of the answer sheet if you disagree with the statement. If you are undecided, do not mark any space on the answer sheet.

There are no right or wrong answers to these questions. Students differ in their opinions on them. Just indicate your own opinion by blacking in column 1 if you agree, and column 5 if you disagree.

QUESTIONS

1. No matter what happens, this subject always comes first.
2. I would rather study this subject than eat.
3. I love to study this subject.
4. This subject is of great value.
5. This subject has an irresistable attraction for me.
6. Ireally enjoy this subject.
7. This subject is profitable to everybody who takes it.
8. This subject develops good reasoning ability.
9. This subject is very practical.
10. Any student who takes this subject is bound to benefit.
11. This subject teaches me to be accurate.
12. This subject is a universal subject.
13. This subject is a good subject.
14. All of our great men studied this subject.
15. This is a cultural subject.

16. All lessons and methods used in this subject are clear and definite.
17. This subject is O. K.
18. I am willing to spend my time studying this subject.
19. This subject is not receiving its due in public schools.
20. This subject saves time.
21. This subject is not a bore.
22. This subject is a good pastime.
23. I don't believe this subject will do anybody any harm.
24. I am careless in my attitude toward this subject but I would not like to see this attitude become general.
25. I haven't any definite like or dislike for this subject.
26. This subject will benefit only the brighter students.
27. My parents never had this subject so I see no merit in it.
28. I could do very well without this subject.
29. Mediocre students never take this subject so it should be eliminated from the schools.
30. The minds of students are not kept active in this subject.
31. I am not interested in this subject.
32. This subject does not teach you to think.
33. This subject is very dry.
34. This subject reminds me of Shakespeare's play "Much Ado about nothing."
35. I have no desire for this subject.
36. I have seen no value in this subject.
37. I would not advise anyone to take this subject.
38. This subject is based on "fogy" ideas.

39. This subject is a waste of time.

40. It is a punishment for anybody to take this subject.

41. This subject is disliked by all students.

42. I look forward to this subject with horror.

43. I detest this subject.

44. This subject is the most undesirable subject taught.

45. I hate this subject.

APPENDIX 7

Attitude Posttest

Instructions to the Student

Please read each of the following statements carefully. Blacken in the first column of your answer sheet if you agree with the statement. Blacken in the fifth column of the answer sheet if you disagree with the statement. If you are undecided, do not mark any space on the answer sheet.

There are no right or wrong answers to these questions. Students differ in their opinions on them. Just indicate your own opinion by blacking in column 1 if you agree, and column 5 if you disagree.

Questions

1. I am "crazy" about this subject.
2. The very existence of humanity depends upon this subject.
3. If I had my way, I would compel everybody to study this subject.
4. This subject is one of the most useful subjects I know.
5. I believe this subject is the basic one for all high school courses.
6. This is one subject that all young Canadians should know.
7. This subject fascinates me.
8. The merits of this subject far outweigh the defects.
9. This subject gives pupils the ability to interpret situations they will meet in life.
10. This subject will help pupils socially as well as intellectually.

11. This subject makes me efficient in school work.
12. There are more chances for development of high ideals in this subject.
13. This subject is interesting.
14. This subject teaches methodical reasoning.
15. This subject serves the needs of a large number of boys and girls.
16. All methods used in this subject have been thoroughly tested in the classroom by experienced teachers.
17. This subject has its merits and fills its purpose quite well.
18. Every year, more students are taking this subject.
19. This subject aims mainly at power of execution or application.
20. This subject is not based on untried theories.
21. I think this subject is amusing.
22. This subject has its drawbacks, but I like it.
23. This subject might be worthwhile if it were taught right.
24. This subject doesn't worry me in the least.
25. My likes and dislikes for this subject balance one another.
26. This subject is all right, but I would not take any more of it.
27. No student should be concerned with the way this subject is taught.
28. To me this subject is more or less boring.
29. No definite results are evident in this subject.
30. This subject does not motivate the pupil to do better work.
31. This subject has numerous limitations and defects.

32. This subject interferes with developing.
33. This subject is dull.
34. This subject seems to be a necessary evil.
35. This subject does not hold my interest at all.
36. The average student gets nothing worth having out of this subject.
37. All the material in this subject is very uninteresting
38. This subject cannot benefit me.
39. This subject has no place in the modern world.
40. Nobody likes this subject.
41. This subject is more like a plague than a study.
42. This subject is all bunk.
43. No sane person would take this subject.
44. Words cannot express my antagonism toward this subject.
45. This is the worst subject taught in school.

Scoring Keys for Attitude Tests

Form A

The individual score is obtained by determining the median of the scale values of the items endorsed by the person.

Question	Scale Value	Question	Scale Value
1	10.3	24	5.8
2	10.2	25	5.5
3	9.8	26	4.7
4	9.7	27	3.6
5	9.6	28	3.5
6	9.4	29	3.4
7	9.2	30	3.3
8	9.1	31	3.1
9	9.0	32	2.9
10	8.9	33	2.8
11	8.8	34	2.6
12	8.7	35	2.5
13	8.5	36	2.4
14	8.4	37	2.2
15	8.3	38	2.1
16	8.1	39	1.6
17	7.9	40	1.5
18	7.7	41	1.3
19	7.6	42	1.0
20	7.3	43	0.8
21	6.8	44	0.7
22	6.5	45	0.6
23	6.1		

Form B

The individual score is obtained by determining the median of the scale values of the items endorsed.

Question	Scale Value	Question	Scale Value
1	10.3	24	5.9
2	10.3	25	5.5
3	9.8	26	4.7
4	9.7	27	3.6
5	9.6	28	3.5
6	9.4	29	3.4
7	9.2	30	3.3
8	9.1	31	3.1
9	9.0	32	2.9
10	8.9	33	2.8
11	8.8	34	2.6
12	8.7	35	2.5
13	8.5	36	2.4
14	8.4	37	2.2
15	8.3	38	2.1
16	8.1	39	1.6
17	7.9	40	1.5
18	7.7	41	1.3
19	7.6	42	1.0
20	7.3	43	0.8
21	6.7	44	0.7
22	6.5	45	0.6
23	6.0		