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Chapter One

INTRODUCTION

Throughout this study we were concerned with computer-assisted instruction (CAI) where the term CAI was used as defined by Hicks & Hunka (1970) to mean "teaching and learning activities aided directly by a digital computer". In particular we took CAI to mean direct student interaction with a teletypewriter.

Our purpose in this study was to examine the relative effectiveness of two instructional strategies in the teaching of the rules of signs for the multiplication of integers. Our long term intention was to use this study as part of a mosaic of studies investigating instructional strategies. The mosaic of studies was to serve as a step in the process of identifying an optimum instructional strategy, should it exist.

The project compared two instructional strategies in CAI: an expository approach and a tutorial approach.

In the first approach, the 'expository' method refers to an instructional strategy that consisted of a general statement and several examples of that generality. Questions may or may not be subsequently asked the student.

In contrast, the 'tutorial' method consists of a strategy that is constituted by several examples (usually posed as questions to the student) and then a generalization of these examples. The latter is also posed as a question.

In a previous study, Collins (1974) compared varieties of the two strategies for the teaching of South American Geography to high school students. The results of his study were supportive of the tutorial strategy as being superior to the expository strategy.

Consequently, a second problem will be to examine the possibility of further generalizing the findings of Collins' study across different subject areas.

Related Research and Development Activity

Molnar (1968) held that the "most significant contribution of CAI has been an indirect one. As researchers tried to programme material for the computer, it soon became apparent that psychological theories of learning were not entirely adequate and what was required was a theory of instruction". This position is further supported by Stolurow (1969) who contended we lacked a "useful set of empirically validated principles of instruction that could form the basis of a theory of teaching". Stolurow added that one of the vital functions of CAI was to develop an empirically-based theory of teaching designed to meet the requirements of individual learners.

For many years research in CAI consisted for the most part of comparison studies involving user attitudes and studies comparing traditional approaches to that of CAI (Judd et al, 1970). Although they formulated that particular viewpoint in 1970, many studies after this date still deal with user attitudes toward CAI and/or are studies comparing CAI to traditional approaches to teaching. The obvious objection to comparing CAI to traditional teaching is in the structure of each. While CAI is well defined in structure, traditional teaching is an ill-defined term in that it may include varying degrees of interaction with the teacher, the use of learning packages, and/or other mediated materials. Objections to attitude studies are primarily that there is low correlation between attitude and learning achievement. Kockler (1973) also found a significant attitude improvement to CAI from pretest to posttest in an experimental group of prospective primary teachers. Taylor (1974) also found students and teachers highly enthusiastic toward CAI as a means of instruction. Other conclusions of the Taylor study found that the retention of material learned does not appear to be high for CAI as for traditional instruction.

Peelie (1972) maintained that since researchers were for the most part only concerned with the question of whether or not CAI should be used and that since few researchers were concerned with how to use CAI, we were still 'in love' with our creation.

With the development of CAI, many misconceptions were commonplace. Hansen & Johnson (1971) offer the following as myths resulting from this development. They hold that these myths must be destroyed if progress is to be made:

- the teacher is total instruction
- the computer is designed for instruction
- there is one best language for computer usuage, and
- the biggest cost of computer implementation is the cost of hardware.

Of these, the first three require little if any, comment. During the last five years attitudes have been changing to reject the teacher as 'total instruction'.

As more information is reaching the public, the idea that the digital computer is a god that can do anything is being rejected. The high cost of computer implementation is best refuted by Gilman (1969) who points out that CAI opponents continually present arguments dealing with the high cost of CAI development and usuage, rather than the cost of implementation per se. Gilman maintains that if the cost of implementing CAI is calculated on a per capita basis, an acceptable cost-accountable figure is reached. Mere consideration of the cost of implementing CAI does not balance this against the benefits of CAI. CAI costs vary considerably. They may be high or they may be as low as $1.00 per contract hour (OISE remedial math system, (McLean, 1976)). While CAI costs may be high, beneficial results may also be high enough to warrant its implementation. The same

cost benefit approach applies to other mediums. A low cost may result in low benefit within the instructional system.

One consistent result of CAI studies is that instruction time is compressed to achieve the same levels of performance. Kockler (1973) and Netusil (1974) found that instruction time was reduced significantly in a mode of instruction that is computer interactive when compared to traditional instruction. Taylor (1974) also found that when students are permitted to proceed at their own rate, they will generally learn more rapidly through CAI than through traditional instructional methods.

Assuming one accepts the four modes of instruction as outlined by Ensor & Stanfield (1968) to be (a) 'simulation' as defined to be any attempt to replace empirical activities with symbolic representations provided by the logical capabilities of the computer; (b) 'problem solving' where the computer is used as a problem-structuring device; (c) 'drill and practice' where the computer is used to automatically provide the problem-solving routines to be mastered by the student; and (d) the 'tutorial' mode which is an outright attempt to replace the teacher, the question arises as to which of these modes is served by CAI. Ensor & Stanfield contend that CAI can be used effectively in all four modes. Taylor (1974), on the other hand, holds that CAI is more effective in the tutorial and drill and practice modes than in problem solving and simulation; and that CAI is more effective for low ability students than for middle and high ability students.

One strength of CAI lies in the fact that it permits the student to proceed at his own pace. If we use CAI as a mode of communication rather than a page-turning device, we can better accomodate the needs of the individual learner. (Gentile, 1961) The strength of CAI is in the computer which "can analyze and adapt teaching sequences to the learning abilities of each person, thus insuring true compatibility of individual and education". (Filep, 1967) While Filep's statement is rather sweeping, if one replaces the word 'education' with

'instruction', Filep's claim is strengthened considerably. This position is further clarified by Kalin (1969) who outlines the philosophy of CAI and individualized instruction, as asserting that:

" 1. Each student should study the subject matter for which he is prepared;

2. each student should study the subject matter at 'his own rate';

3. each student should achieve to the extent of his own ability."

That sequencing of instruction is vital to effective teaching is questioned only in degree of importance. Merrill & Wood (1974) define instruction as consisting of learner aptitude, content structure, delivery system and instructional sequence. Mitzel (1974) holds a slightly different viewpoint and calls the presentation strategy an "individual difference variable".

Any attempt to decide upon an instructional strategy might first question whether or not the instruction should be student controlled or prescribed entirely by the designer. Beard (1973) found that if students were given the option of choosing lesson sequences, no significant difference in any of three levels of student control was found. The three levels were: total student selection and total student selection with a course programme provided. The students with total freedom did not choose to alter sequences significantly.

This position is indirectly supported by Hansen (1970) who explains that "Stolorow, Smallwood, and Suppes" would suggest that we prescribe the optimal selection of learning events for each student. The investigators claim that once having understood the students' basic learning processes that the educator....can best describe this prescription for instruction.

In particular Dean (1969) constructed a study to determine the effective difference of learner versus teacher controlled arithmetic practice. In his study, the students were taught arithmetic skills using CAI. Both groups were

permitted to decide upon their rate of progress through the instructional materials. The student in the control group proceeded to a more difficult problem only after he had successfully done five variations of the current problem while the student in the experimental group was permitted to decide how much practice he should do on each problem type. The students were pretested, posttested and were later given a retention test.

Dean's results shows that the novelty of the arithmetic skills led the fourth graders under learner control. Fifth graders in both groups spent about the same time practising. Sixth graders spent much less time practising under learner control than sixth graders under teacher control.

Of particular interest "is the fact that, there was no significant difference in the posttest scores". One can only interpret this fact to mean that for the teaching of arithmetic skills, learner control is not a significant factor in the acquisition of these skills nor is the number of repetitions of a prototype arithmetic skill a factor in the mastery of that skill.

The use of CAI for the teaching of arithmetic shows results consistent with findings in other content areas. In a report of CAI for elementary schools, National Learning Systems (1969) reports that the CAI group was four months ahead of the non-CAI group at the end of four months of tests conducted between February and June, 1969 in Waterford, Michigan. National Learning Systems further reports that there is a close correlation between computational skills and problem solving gains and that drill and practice arithmetic significantly affects performance in computational skills.

Limited attempts to identify an optimum strategy produced varying results according to subject area and population. Phillips and Kane (1973) found no optimum teaching strategy for the teaching of elementary mathematics and Lawlor (1971) found no optimum strategy for the teaching of health education at the

collegial level. Lawlor (1971) however, did find that CAI groups did better than his control groups who were under instruction other than CAI. Atkinson (1973) postulated an instructional strategy which he called an adaptive teaching system. This strategy took into account the subject's response history in deciding upon which items to present from trial to trial. A study using 120 undergraduates in four experimental groups was conducted at Stanford. The instructional material was 84 German-English items displayed in seven groups of twelve. The study consisted of an instructional session and a test session schedule one week later. The groups were separated according to sequence strategy. In the first strategy the student is cycled through a set of items in random order. The second strategy permitted the student to determine the sequence of instruction. The basis of the third and fourth sequencing strategies is a mathematical model of learning. The third strategy was based on the assumption that all vocabulary items were of equal difficulty while the fourth strategy assumed that some items were more difficult than others. Of particular interest in the experiment were the third and fourth strategies.

The observed results were of practical significance. The proportion of correct responses was greatest for the random sequence, second highest for the optimal strategy with equal parameters, third highest for the self-selection strategy and poorest for the optimal strategy with unequal parameters.

The order of results was highly significant $F(3,116) = 21.3$, $P < .001$ for the instructional session. The results on the delayed test are completely reversed. The optimal strategy with unequal parameters ranked highest, self-selection was second, the optimal strategy with equal parameters was third and random sequencing was last. Again, these results were also highly significant $F(3,116) = 18.4$, $P < .001$. The observed pattern of results is expected. The optimal strategy with unequal parameters produced the lowest proportion of correct responses on the

instructional session because it attempted to identify and test those items that had not yet been mastered. The self-selection strategy required the student to identify his difficulties and practise those vocabulary segments. Again, the order of results on the delayed test were expected.

The 'tutorial' strategy used in this study is a modification of Atkinson's adaptive teaching sequence. Rather than sequence the order of vocabulary items in blocks of twelve, the 'tutorial' strategy attempted to identify modules of information that were not as yet mastered by the student. The student was then branched through that module. Upon mastery of the topic of the module the student was branched to the next module. The order of the modules was specified by the designer. The strategy chose which modules the student needed to complete to master the content of the lesson.

In a previous study, Collins' (1973) compared two instructional strategies that he called 'Block-test' and 'tutorial'. His 'Block-test' strategy was for the most part, what is termed an expository strategy in this study. Collins' 'tutorial' strategy was an attempt to copy instructional strategies used by a tutor.

In an experiment using 8 subjects, the Collins' tutorial strategy was shown to be a significant factor ($F(1,7) = 17.53$, $P < .01$) accounting for the different scores between pretest and posttest for each subject. The subject matter used was South American Geography. This study replicates the study conducted by Collins (1973). It concentrates on the acquisition of information and skills via CAI using two distinctly opposed instructional strategies. It attempts to provide similar controls for sample and population and tries to determine the extent to which Collins' results apply to a different population - English students from St. Laurent, as opposed to Cambridge high school students and the extent to which Collins' results apply to a different subject area.

Problem Statement

We are aware of some factors determining the place of CAI in education and of the fact that instructional strategies are a vital element of CAI. The purpose of this study is to determine the superiority of either the 'tutorial' or 'expository' strategies in the teaching of the rules of multiplication of integers. This study will fit into a mosaic of studies examining the role of instructional strategies of CAI.

Objectives

The hypotheses for this study can be stated:

1) In CAI, the 'expository' and 'tutorial' approaches result in equally effective learning of the rules of multiplication of intergers. (Null hypothesis)
2) In CAI, the 'expository' approach results in more effective learning of the rules of multiplication of integers than does the 'tutorial' approach. (Negative hypothesis)
3) In CAI, the 'tutorial' approach results in more effective learning of the rules of multiplication of integers than does the 'expository' approach. (Positive hypothesis).

The main objective of this study is to prove the 'tutorial' approach does result in more effective learning of the rules of multiplication of integers through CAI than does the 'expository' approach.

The theoretical justification lies in the fact that the student is oriented by being shown what to look for in a lesson using a 'tutorial' strategy; it is expected that the leading questions act as "advanced organizers" for the major content of the lesson. (Ausubel, 1969).

In the 'tutorial' strategy the student is asked a question. If he correctly answers the question, a second question is generated. With the first incorrect

response the student is given diagnostic material and information to correctly identify the answer to the question. Because that question first served as an alert, the student should be able to assimilate the information more quickly than had he first been given the information only.

Operational Definition of Variables

'Tutorial' Approach: refers to the CAI lesson that uses as it teaching strategy, a sequence of questions. The leading questions deal with examples and the final questions deal with the general principle involving the examples.

'Expository' Approach: refers to the CAI lesson that uses as its teaching strategy, the exposition. A general statement is made. The examples of that statement are given and finally, questions relating to the examples may or may not be asked the student.

Effective Learning: refers to the ability to achieve a prescribed level of performance and in a prescribed time.

In this case, the performance refers to the ability to correctly multiply integers. (i.e. positive or negative signed whole numbers). The level of performance refers to a score of 8/10 correct on the criterion test.

The hypothesis can now be restated as the predictions:

A 'tutorial' teaching strategy will result in more effective learning of the rules of multiplication of integers than will an 'expository' strategy.

Chapter Two

Population and Sample

Subjects for this study were 58 English-speaking, Secondary I (ages 11-13 years) students from Father MdDonald Comprehensive High School in Saint Laurent, Quebec. The population from which the sample was drawn is relevant in that all Secondary I students are taught the lesson content during the course of the school year.

The sampling procedure involved selection from six (6) Secondary I classes. Each class group was randomly divided into two treatment groups. The randomization process was carried out by using a table of random numbers. Randomization was verified by checking the male/female ratio in each sample, as well as, by comparing the subjects's mean grade results of first and second term examinations. The students were placed in either treatment group, according to whether or not the number in the random sequence was even or odd. Each group then followed a CAI lesson using either and expository or a tutorial strategy.

Procedure

The 58 subjects, in two groups of 29, used the computer at Concordia University in Montreal. Subjects were asked to take one lesson at a terminal. Upon completing the lesson, each subject was given a criterion test. The same criterion test was given to both treatment groups. The study was conducted in one non-school day, since subjects were not available during school time.

Data was scores on a criterion test that was administered at the end of the CAI lesson. The test measured the ability to correctly multiply integers.

Scores on first and second term exams were collected for each subject as well as, a record of the time taken to complete the lesson.

Design

The design is modified pretest-posttest design outlined in Campbell & Stanley (1963). The design is modified in that two treatment groups are used. This design can be diagrammed as

$R\ O_1\ X_1\ O_3$

$R\ O_2\ X_2\ O_4$

(Each line is a sequence of operations carried out on each group of subjects.)

The treatment was accorded to both groups. Subjects were screened so that no one having any previous exposure to CAI participated in the study. Consequently, both groups were subjected to a new experience counteracting any possible differential Hawthorne Effect due to new experience.

Subjects were randomly (R) assigned to either treatment (a) or treatment (b). Before treatment was accorded any subject he/she was tested (O_1, O_2) to insure that he/she had the minimal knowledge necessary for the successful completion of the lesson. The treatment (a) group was instructed via CAI using a tutorial strategy (X_1), while the treatment (b) group was instructed in CAI using the expository approach (X_2).

Post-testing (O_3, O_4) of each group measured the ability of students to correctly multiply integers.

Variables

Independent: 'tutorial' verses 'expository' approach in CAI.

Dependent: performance on criterion test.

Control: 1) pre-knowledge of basic mathematical concepts; subjects lacking this minimum knowledge were rejected.

2) previous exposure to CAI; students were asked to indicate previous exposure to CAI.

3) Pre-knowledge of lesson content; subjects with this knowledge were rejected.

Moderator: 1) Time spent interacting with the computer.

2) previous grades on first and second term examinations.

3) sex

4) age

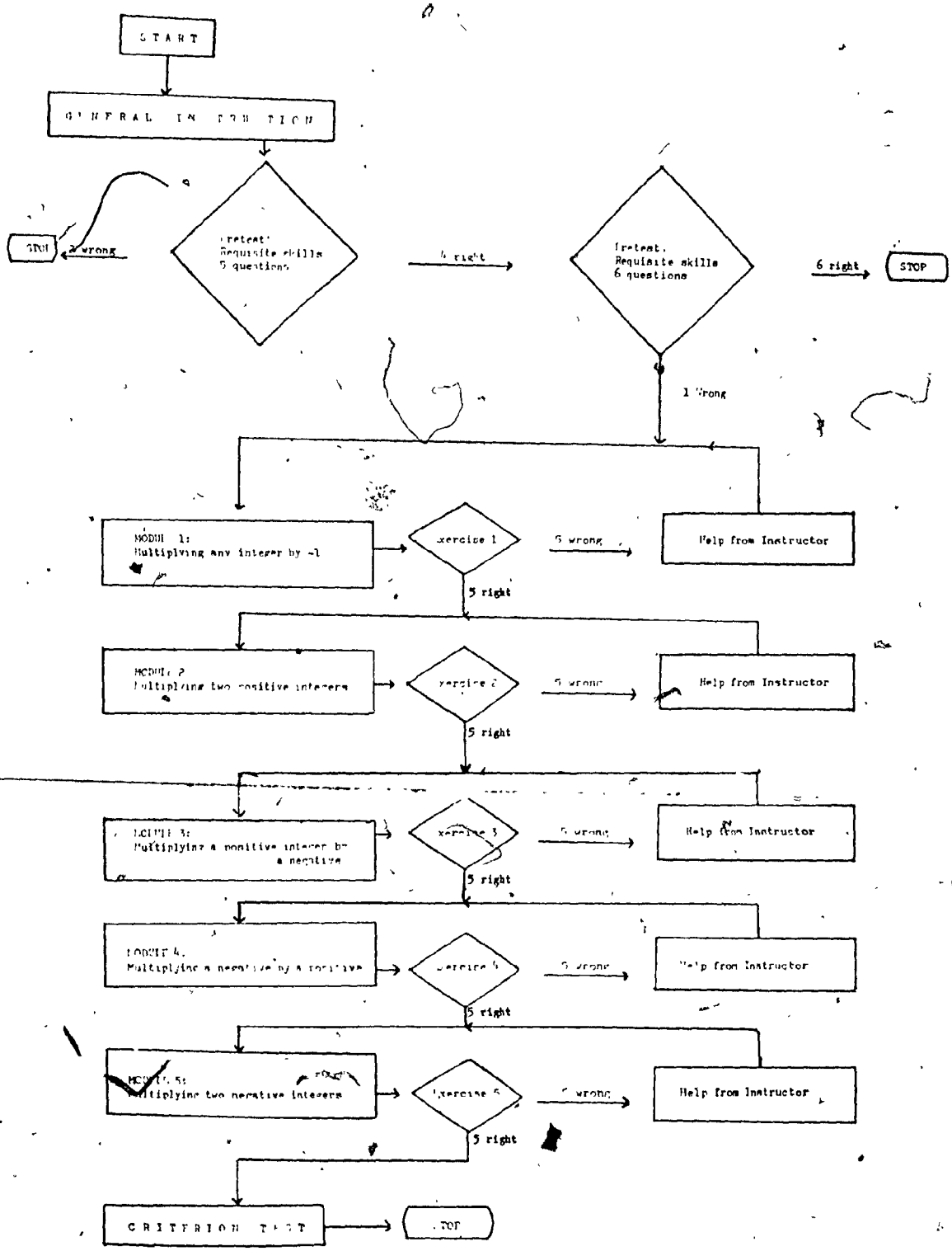
Lesson Structure

For purposes of control, both lessons, expository and tutorial were isomorphic. The flow chart (Fig. 1) that follows outlines the

lesson. The lesson was controlled by a procedure file called XMULT (Appendix I) which called the various modules, exercises and criterion test, as they were needed.

Figure 1

Lesson structure for expository and tutorial approaches



The subject was logged on and given general instructions; then pre-tested to insure that he/she had the requisite skills necessary to complete the lesson and pre-tested to guarantee the lesson content had not already been mastered by the subject.

Module I was then presented using either an expository or tutorial strategy, depending upon which treatment group the subject belonged. Subsequent modules (2 - 5) used the same strategy as the initial module. The expository lesson is called MULTI (Appendix 2) and the tutorial lesson is called INQR (Appendix 3). Each module was followed by an exercise pertaining to the content of the module. The same exercises (Appendix 4 - 8) were used for both treatment groups.

Although the lessons themselves provided remedial information within each module, the exercise segments were programmed to stop the lesson should the subject experience difficulty in correctly identifying products. After remedial help from the instructor, the student would begin the exercise anew and the lesson would continue. During the actual experiment, none of the subjects required this remedial help.

Upon completing the lesson, the student was immediately given the criterion test (Appendix 9 - 10) which was administered at the terminal. Reliability of the criterion test had been determined using a sample chosen from the population. The subject matter was taught in a classroom to a group of 16 subjects, selected at random. The item difficulty of various questions was determined and a Kuder-Richardson (KR 20) Reliability test was performed.

Figure 2

Table 1

'Kuder - Richardson ' 20'

Applied to Criterion Test development

	1st trial of test		2nd trial, revised test	
item no.	no wrong	degree of difficulty	no. wrong	degree of difficulty
1	3	.1875	3	.1875
2	2	.125	2	.125
3	2	.125	2	.125
4	3	.1875	2	.125
5	1	.0625	2	.125
6	0	0	2	.125
7	5	.3125	4	.250
8	2	.125	3	.1875
9	0	0	2	.125
10	1	.0625	2	.125

$k = 10$ | $k = 10$

$\Sigma pg = .9648$ | $\Sigma pg = 1.2572$

$\sigma^2 = 3.575$ | $\sigma^2 = 1.777$

$m = 16$ | $m = 16$

$\bar{x} = 8.875$ | $\bar{x} = 8.125$

$K\text{-}R_{20} = .8112$ | $K\text{-}R_{20} = .4594$

(Dick & Hagerty, 1971). Two items were changed in the original criterion test because of zero difficulty. The revised criterion test was again given to the 16 subjects and new coefficients of relative item difficulty were recalculated as well as new K-R 20 coefficients. The results of the calculations are contained in Table 1.

The reliability coefficient for the retest was found to be .46, considerably lower than on the original test, however, the revised test contains no questions with zero difficulty. The retest reliability coefficient is a conservative estimate of true reliability because of the homogeneous nature of the test group and consequently may be accepted.

The content validity of the criterion test was not correlated because of the nature of the test. Since all ten test items consisted of identifying mathematical products, the calculation of a validity coefficient was not considered to be necessary. (The target task was the test task.)

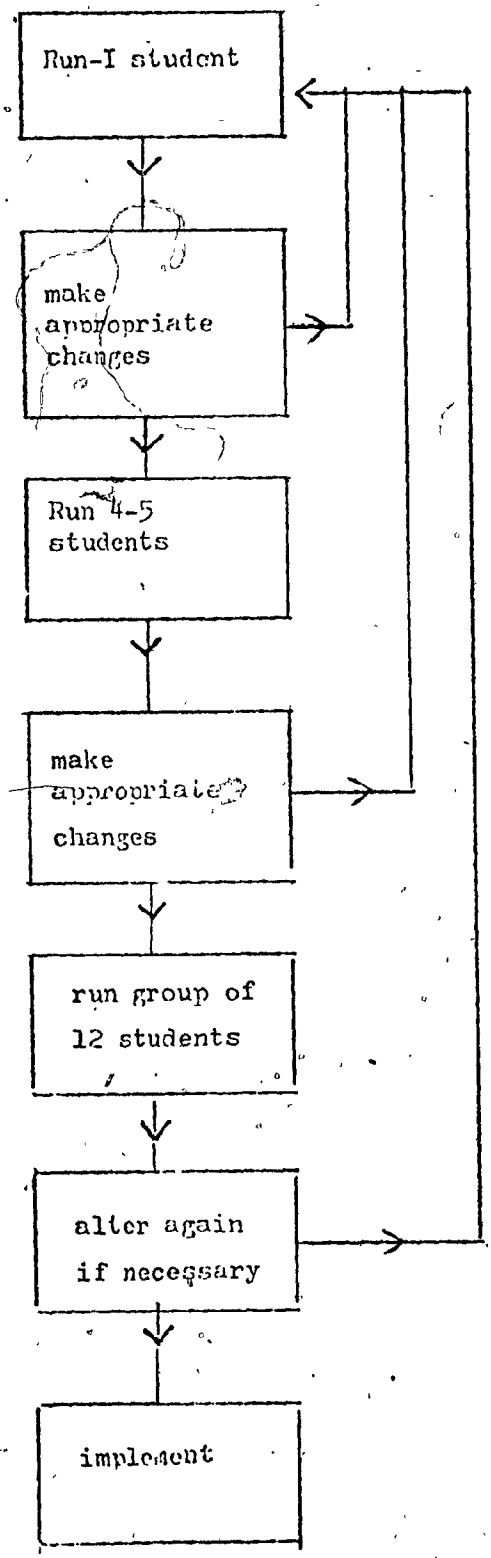
DEVELOPMENT OF PROTOCOLS

The two lesson protocols were evaluated prior to conducting the experiment. The lessons were developed using the same examples and same steps in each lesson. The only difference was in the instructional strategy - one lesson used and expository strategy, the other used a tutorial strategy.

The following model (Figure 3) was used for the development of the lesson protocols:

Figure 3

Model of Protocol Development



The individual protocol sturctures can be diagrammed using the notation:

Eg:	expository generality (a presented rule or postulate)
Ei:	expository instance (a presented example)
Ig:	inquisitory generality (questioning rule or postulate)
Ii:	inquisitory instance (questioning postulate)

To avoid confusion the expository instance were subscripted. The beginning of each module re-initiated the subscripts. Optional sequences and branches are indicated using parenthesis.

The structure of the two protocols is illustrated so that they can be compared.

Module I	expository approach :	Ei_1, Ei_2, Ei_3, Ei_4, (Ei_{4A}) Eg, Ei_5, Ei_6, Ei_7, Ei_8, (Ei_9, Ei_{10}, Ei_{11}, Ei_{12})
	tutorial approach :	Ii_1,(Ei_{1A}, Ei_2,) Ii_2, (Ei_3) (Ei_{3A}) Ig, (Ei_4, Ei_5, Ei_6, Ei_7, Ei_8) (Ei_9, Ei_{10}, Ei_{11}, Ei_{12})
Module 2	expository approach :	Ei_1, Ei_2, Eg_1(Ei_3, Eg_1, Ei_4, Eg, Ei_5, Eg_2)

Module 2 tutorial approach : $Ii_1, Ii_2, Ig, (Ei_1, Eg_1, Ei_2, Eg (Ei_3, Eg, Ei_4, Eg_1) Ig_1)$

Module 3 expository approach : Ei_1, Eg_4, Ei_2, Ii_3

tutorial approach : $Ii_1(Ei_{1A}) Ii_2 (Ei_{2A}, Ii_3) Ig_1 (Ei_4, Eg_1, Ei_5, Eg_1, Ei_6, Eg\ Ei_7, Eg_1) Ig_1)$

Module 4 expository approach : $Ei_1, Eg_1, Ei_2, Eg_4, Ii_3$

tutorial approach : $Ii_1(Ei_{1A}) Ii_2 (Ei_{2A}) Ig_1 (Ei_4, Eg_1, Ei_5, Eg_1 (Ei_6, Eg_1, Ei_7, Eg_1) Ig_1)$

Module 5 expository approach : $Ei_1, Eg_1, Ei_2, Eg_1, Ii_3$

tutorial approach : $Ii_1 (Ei_{1A}) Ii_2 (Ei_{2A}) Ig_1 (Ei_4, Eg_1, Ei_5, Eg_1 (Ei_6, Eg_1, Ei_7 Eg_1) Ig_1)$

As outlined earlier, upon completion of a module, the subject would be branched to an exercise segment. The purpose of the exercise was to give the subject an opportunity to practice the content of the completed module. The subject would then be branched to the next module.

The teaching model implicit to the development of the modules is the classroom. The basic model may be referred to as "explanation, demonstration, assimilation". The rationale for the number of repetitions of examples both in the expository and tutorial modules is based on real classroom experience.

In the ideal situation the module provides an indefinite number of examples, however, due to the nature of CITCAN a limited number of examples are used.

An intuitive decision is made limiting the number of examples. If the student cannot grasp the concept remedial help is called for. Under this circumstance the student would be branched out of the lesson and given personal attention.

CHAPTER THREE

Results

The data collected for each group is shown in Table 2, broken down by instructional strategy, age and sex. (Thirteen and fourteen year olds were grouped together because of the few fourteen year olds in the population.)

The moderator variables in the study were time spent interacting at the terminal, previous grades on first and second term math examination (pre-score) sex and age. By subdividing the samples according to age and sex, we can account for any effect on the final scores due to these factors. The effect of time and pre-score on criterion test scores is countered by determination of regression equation for each cell, by determination of a residual for each score and by adding this residual to the score predicted by the regression equation using the sample mean and the sample mean time. All tests are computer administered and all data is collected on line.

An analysis of covarience was performed as outlined in Marascuilo (1971). Regression analysis of the covariates (times, pre-secores) was conducted and regression coefficients were found for each cell and both samples. The coefficients are contained in Table 2. The corrected scores were found after determining the residual of each score. By using the observed values for time and pre-score in the regression equation of each cell, we obtained a predicted score for each subject. The difference between the actual and predicted scores is the residual. Using the sample mean time and mean pre-score in the regression of each cell yields another value which when added to the residual gives us the corrected score. An analysis of variance was then conducted on the corrected scores.

Figure 4

Table 2 Summary of Results

Male, 12	Male, 13 - 14	Female, 12	Female 13 - 14
N = 5	N = 11	N = 5	N = 8
$\bar{X}$ = 9.0	$\bar{X}$ = 9.0	$\bar{X}$ = 9.2	$\bar{X}$ = 8.7
Corrected $\bar{W}$ = 9.0 Score	Corrected $\bar{W}$ = 8.9 Score	Corrected $\bar{W}$ = 9.1 Score	Corrected $\bar{W}$ = 8.7 Score
Predicted = 9.0 Score	Predicted Score = -.0348 Y -.0477 Z+1 13.835	Predicted Score = -.0994 Y + .0201 Z + 10.947	Predicted Score = -.0292 X -.0149 Z + 109

EXPOSITORY GROUP

N = 29
$\bar{X}$ = 8.9
Corrected W = 8.9
Mean Time = 34.0
Mean Pre-Score = 77.6
Predicted
Score = -.0035 Y
-.02546 Z
+ 10.10379

Male, 12	Male, 13 - 14	Female, 12	Female, 13 - 14
N = 5	N = 10	N = 7	N = 7
$\bar{X}$ = 9.6	$\bar{X}$ = 9.6	$\bar{X}$ = 9.7	$\bar{X}$ = 9.1
Corrected W = 9.4 Score	Corrected W = 9.5 Score	Corrected W = 10.0 Score	Corrected W = 9.6 Score
Predicted Score = -.0735 Y + .0197 Z + 10.3199	Predicted Score = .0361 Y -.0112 Z + 9.9191	Predicted Score = .0806 Y -.0247 Z + 8.8244	Predicted Score = -.1596 Y + .0024 Z + 14.6212

TUTORIAL GROUP

N = 29

X = 9.5

Corrected W = 9.6

Mean Time = 33.8

Mean Pre-Score = 77.7

Predicted
Score = -.01365 Y
-.0203 Z
+ 11.2631

A complete table of raw data is found on Page 78. Using as an example, the first subject in the tutorial approach we get a predicted score of 9.044. With a time of 35 and a pre-score of 62% the predicted score = - .0735 (35) + .0197 (62) + 10.3199 = 9.044. Since the actual score was 9, the residual for this subject is -.044. Now using the sample mean time of 33.897 and the sample mean prescore of 77.741 in the same regression equation, we get a value equal to -.0735 (33.897) + .0198 (77.741) + 10.3199 = 9.313. Adding the residual of -.44, we obtain a corrected score of 9.313 - .044 = 9.269. This procedure was followed for all scores with the exception of the twelve year old males in the expository approach. Since all scores in that cell were constant, the regression equation for that cell is also constant, the residual is zero for all subjects and the predicted score is 9.000.

An analysis of variance was then performed on the corrected scores. The results of the 4 x 2 analysis are listed below. The A-level factor is the effect of age and sex while the B-level factor is the effect of strategy on outcomes.

FIGURE 5

TABLE 3

Analysis of Variance

Source	df	M.S.	F
A	3	.4224032	.6774287
B	1	6.7146639	10.768637
AB	3	.2084831	.3342583
error	50	.623539	.3342583

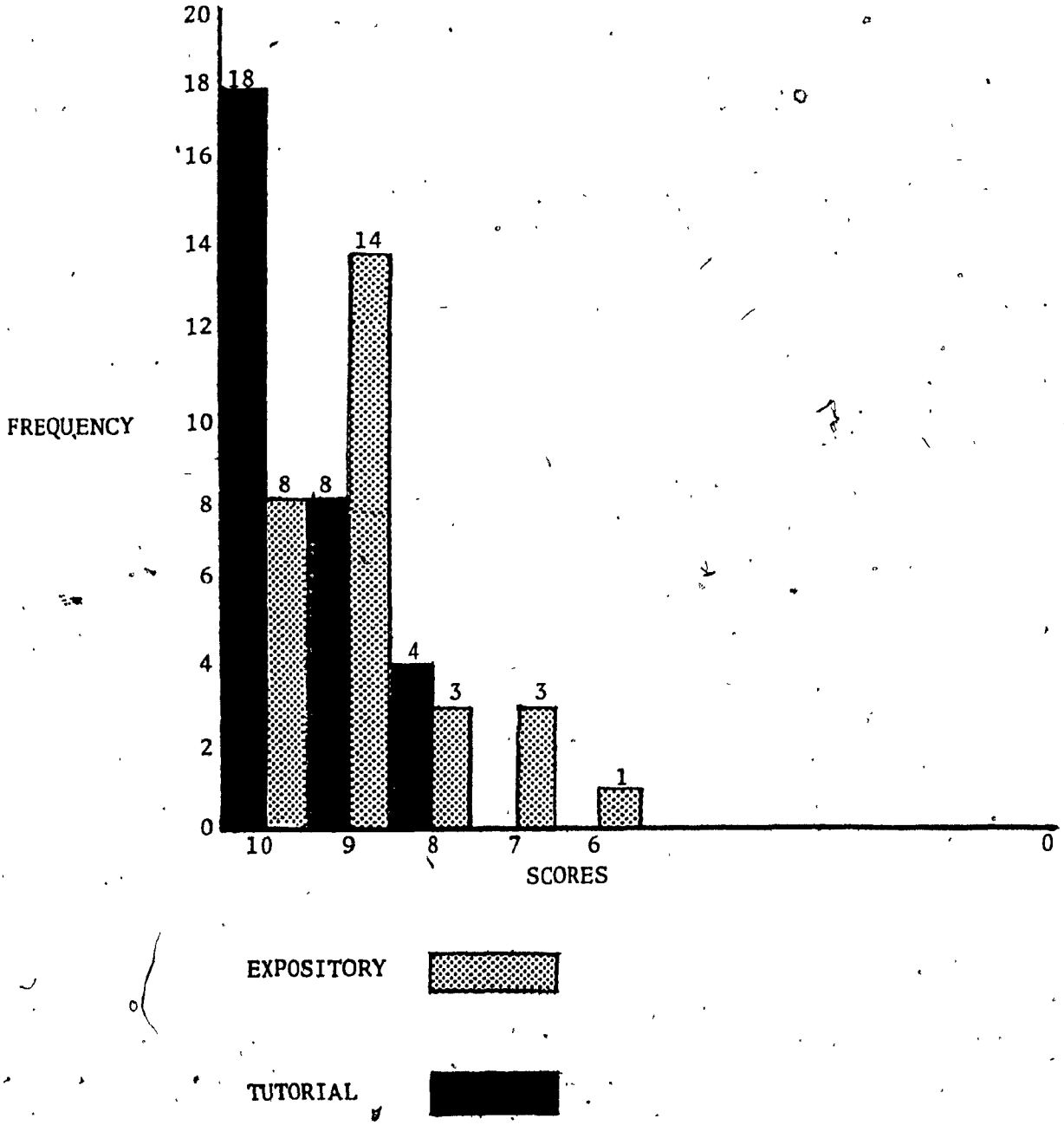
The results of the analysis of variance shows that the effect of strategy on outcomes is very highly significant $F(1,50) = 10.768$, $P < .0025$. In view of the results of studies by Atkinson (1972) and Collins (1974) using instructional strategies similar to the tutorial strategy of this study, this result is not

unexpected. Since the tutorial strategy attempts to identify the student's weaknesses, the student is branched out of the modules whose content he has mastered. Consequently more attention is given to the instruction of items not presently mastered by the student.

The histogram that follows (Figure 6) shows the distribution of raw scores on the criterion test administered at the end of the lesson. The distribution alone shows quite clearly the superiority of the tutorial approach over the expository approach.

FIGURE 6

HISTOGRAM OF DISTRIBUTION OF CRITERION TEST SCORES



Chapter Four

Conclusions & Discussion

Future studies in the area of CAI must observe the caveat that most students have difficulty operating a computer terminal upon first exposure. Many subjects of this study were momentarily perplexed upon learning the standard notation for O (OH) and ø (zero), the use of the carriage return, etc. Fortunately, all subjects recovered sufficiently to be able to follow the lesson, however, future endeavours of this kind will first spend a period of time allowing the subjects to familiarize themselves with the operation of the terminal. The lesson will be given at a second sitting.

This study was conducted in one sitting to handle several uncontrollable factors. Since the subjects were 12-14 years of age, adult supervision was necessary. While subjects were participating in the experiment, they were left to the privacy of the computer terminal with an adult on the floor. A second reason for running the experiment in one sitting was because the subjects were of school age and it was not possible to arrange for the subjects to leave school more than once to participate in the experment. Future replications of this experiment should be done in two sittings - the first to introduce the subject to the use of the terminal, the second sitting to run the experiment. It would be interesting to note if the results would be similar to those reported here, if the experiment is run using a larger number of lessons.

The results of the experiment reported strongly favor the 'tutorial' strategy to the 'expository' in the teaching of the rules of signs for multiplication of integers. The results of Collins' study similarly favor a

tutorial (albeit a slightly differenct strategy) approach in the teaching of South American Geography. Further research must be conducted to determine whether this result is consistant for most subject areas.

The superiority of the 'tutorial' approach can be explained in that the subjects weaknesses are quickly identified and the appropriate instruction is given him. Whenever an area of instruction which the subject has already mastered is reached, that area is skipped. Consequently, more time is spent in relevant instruction. Similar experiments must be conducted using the same strategies, and variations of these strategies to determine whether the results will hold using a different mathematical concept as lesson content, as well as, in different subject areas. Other experiments using different populations are necessary to generalize the results of this experiment. If consistent results can be obtained using different populations, and different subject areas, the superiority of the 'tutorial' approach can be asserted.

The question that logically follows is whether or not a strategy that is a combination 'expository - tutorial' approach would be superior to the two presently under discussion and if so, for what subject areas, for what populations. The implications of such results for instructional designs in areas other than CAI are limited. Television for example, is not suited to tutorial approach while the traditional classroom would benefit. Since the teacher would skip over areas of instruction, while the students who

have mastered, more time would be spent in relevant instruction. Media with little branching available to them stand to benefit little from a tutorial approach while the media (today's machines, etc.) with branching capability is better able to use the tutorial approach.

The results of the study were expected. Although neither approach exhibited marked differences across age or sex groups the tutorial approach was clearly shown to be superior. The histogram (FIG. 6) also showed the tutorial approach to be superior to the expository. Finally the analysis also upheld this conclusion. The time and cost of development was the same for both approaches yet the tutorial approach achieved better results in less interaction time.

Appendix 1

```
GET,XCITCAN/UN=VASSE80.
CALL,XCITCAN.
GET,EXER1/UN=VASSE80.
EXER1.
RETURN,EXER1.
CALL,XCITCAN.
GET,EXER2/UN=VASSE80.
EXER2.
RETURN,EXER2.
CALL,XCITCAN.
GET,EXER3/UN=VASSE80.
EXER3.
RETURN,EXER3.
CALL,XCITCAN.
GET,EXER4/UN=VASSE80.
EXER4.
RETURN,EXER4.
CALL,XCITCAN.
GET,EXER5/UN=VASSE80.
EXER5.
RETURN,EXER5.
CALL,XCITCAN.
GET,EXERTST/UN=VASSE80.
EXERTST.
RETURN,EXERTST.
CALL,XCITCAN.
EXIT.
```

Appendix 2

```
00100 " HELLO
00110* PROGRAM MULTI
00120* THIS PROGRAM USES AN EXPOSITORY STRATEGY
00130* TO TEACH THE RULES OF SIGNS FOR THE
00140* MULPIPLICATION OF INTEGERS.'
00150 TEXT+'
00160+       WELCOME TO A COMPUTER ASSISTED ALGEBRA LESSON.' SINCE
00170+ THIS IS THE FIRST TIME THAT YOU ARE SITTING AT A COMPUTER
00100+ TERMINAL,' HERE ARE SOME BASIC INSTRUCTIONS YOU MUST ALWAYS
00190+ REMEMBER%
00200+
00210+       -WAIT FOR A QUESTION MARK (\) BEFORE YOU TYPE AN ANSWER.'
00220+        -AFTER EVERY ANSWER YOU TYPE,'PRESS THE RETURN BUTTON.'
00230+         IF YOU CAN"T FIND THE RETURN BUTTON,' ASK THE
00240+         INSTRUCTOR FOR HELP.'
00250+        -THE NUMBER ZERO WILL BE TYPED AS 0.'
00260+        -THE LETTER OH WILL BE TYPED AS O.'
00270+        -WHENEVER YOU TYPE A NUMBER,' TYPE THE NUMERAL.'
00280+         IE,' TYPE 10 FOR TEN.
00290+        -IF YOU MAKE AN ERROR,' PRESS THE BUTTON MARKED #ESC#
00300+         AND RETYPE THE ENTIRE ANSWER.'
00310 N NOW LET"S BEGIN.' GOOD LUCK
00320 TEXT+
00330+
00340+       IN ORDER THAT I WILL BE ABLE TO TEACH THIS LESSON
00350+ PROPERLY,' I MUST KNOW WHAT YOU ALREADY UNDERSTAND.' HELP ME
00360+ BY TRYING THE FOLLOWING QUIZ.'
00370+
00380+
```

```
00390+ SIMPLIFY THE FOLLOWING%
00400+ TYPE THE ANSWER ONLY. MAKE SURE YOU TYPE THE SIGN IF THE NUMBER
00410+ IS NEGATIVE AND REMEMBER TO PRESS THE RETURN BUTTON.
00420+      (-7) + (-11) =
00430 " R
00440 V CLR
00450 00480 C -16
00460 00480 C (-18)
00470 00490 W
00480 V LDV V1=V1+1
00490 T        28 + (-9) =
00500 00530 C 19
00510 00530 C +19
00520 00540 W
00530 V LDV V1=V1+1
00540 T        (-17) + 6 =
00550 00580 C -11
00560 00580 C (-11)
00570 00590 W
00580 V LDV V1=V1+1
00590 T TYPE THE OPPOSITE OF -6.
00600 00640 C 6
00610 00640 C +6
00620 W
00630 00650 T NO, THE OPPOSITE OF -6 IS 6.
00640 V LDV V1=V1+1
00650 T TYPE THE OPPOSITE OF 4.
00660 00690 C -4
00670 00690 C (-4)
00680 00700 W
00690 V LDV V1=V1+1
00700 00760 V CMP V1.GE.4
00710 T
```

```
00720 TEXT+
00730+       I'M VERY SORRY BUT YOU ARE NOT YET READY FOR THIS LESSON.
00740+ GOODBYE FOR NOW.
00750 04630 G
00760 T GOOD.  YOU WILL BE ABLE TO FOLLOW THE LESSON.
00770 T
00780 T NOW, TYPE THE FOLLOWING PRODUCTS%
00790 T       (-4) X 2 =
00800 00830 C -8
00810 00830 C (-8)
00820 01110 W
00830 T    (-5) X 20 =
00840 00870 C -100
00850 00870 C (-100)
00860 01110 W
00870 T     3 X (-5) =
00880 00910 C -15
00890 00910 C (-15)
00900 01110 W
00910 T  6 X (-10)
00920 00950 C -60
00930 00950 C (-60)
00940 01110 W
00950 T  (-3) X (-4) =
00960 01010 C 12
00970 01010 C +12
00980 01010 C (12)
00990 01010 C (+12)
01000 01110 W
01010 T    (-5) X (-5) =
01020 01070 C 25
01030 01070 C +25
01040 01070 C (25)
01050 01070 C (+25)
01060 01110 W
```

```
01070 T YOU KNOW ALL THE MATERIAL THAT THIS LESSON COULD POSSIBLY
01080 M TEACH YOU.  SO-I'LL SEND YOU ON YOUR WAY.
01090 T GOODBYE FOR NOW.
01100 04630 G
01110 OTMI V40
01120 TEXT+
01130+      THE PURPOSE OF THIS LESSON IS TO TEACH THE MULTIPLICATION
01140+ OF INTEGERS.  AFTER YOU HAVE COMPLETED THIS LESSON, YOU WILL
01150+ BE ABLE TO CORRECTLY IDENTIFY THE PRODUCTS IN THE SECTION
01160+ YOU JUST TRIED.
01170+
01180+      BEFORE WE CAN DISCUSS MULTIPLICATION, WE NEED TO
01190+ REVIEW SOME BASIC PRINCIPLES.
01200+      RECALL THAT WE CAN EXPAND  4 X 5  INTO 5 + 5 + 5 + 5.
01210+
01220+ OR                4 X 5 = 5 + 5 + 5 + 5
01230+
01240+ TAKING ANOTHER EXAMPLE YOU MAY REMEMBER THAT
01250+
01260+          6 X 2 = 2 + 2 + 2 + 2 + 2 + 2
01270+
01280+ IT FOLLOWS THAT  3 X (-1) = (-1) + (-1) + (-1)
01290+
01300+      WE KNOW HOW TO ADD (-1) + (-1) + (-1) = -3
01310+
01320+ COMBINING THESE TWO FACTS WE ARRIVE AT  3 X (-1) = -3
01330+
01340+              REMEMBER   3 X (-1) = -3
01350+
01360+ WE WILL USE THIS FACT IN A MOMENT.  REMEMBER IT.
01370+
01380+ THE EXPANSION FOR 5 X (-1) IS (-1) + (-1) + (-1) + (-1) + (-1)
01390+
01400+ THIS GIVES US   5 X (-1) = -5
01410+
01420+ IF THIS ISN'T TOO CLEAR, STOP AND THINK ABOUT IT.
01430 T WHEN YOU ARE READY TO CONTINUE, HIT THE RETURN BUTTON.
```

```
01440 T TF YOU CAN"T UNDERSTAND THE LAST STATEMENT, TYPE #HELP#.
01450 L PCR
01460 01500 A HELP
01470 01500 A #HELP#
01480 01580 A (CR)
01490 01430 I GRY
01500 TEXT+
01510+    WE HAVE THAT  5 X (-1) = (-1) + (-1) + (-1) + (-1) + (-1)
01520+
01530+ YOU SHOULD KNOW THAT  (-1) + (-1) + (-1) + (-1) + (-1) = -5
01540+
01550+  COMBINING THESE TWO FACTS, WE ARRIVE AT
01560+                              5 X (-1) = -5
01570 T
01580 L ICR
01590 TEXT+
01600+  THESE TWO FACTS SUGGEST THE FOLLOWING PROPERTY OF -1
01610+
01620+ #THE PRODUCT OF ANY INTEGER AND -1 IS THE OPPOSITE OF THAT INTEGE
#.
01630+
01640+  USING THIS PROPERTY OF -1, WE GET%
01650+
01660+                        5 X (-1) = -5
01670+
01680+                          2 X (-1) = -2
01690+
01700+                        6 X (-1) = -6
01710+
```

```
01720+                    18 X (-1) = -18
01730+
01740 N WOULD YOU LIKE MORE EXAMPLES\ TYPE YES OR NO...
01750 01720 01880 A YES
01760 01940 A NO
01770 U
01780 01750 N,ANSWER THE QUESTION...WOULD YOU LIKE MORE EXAMPLES...
01790 TE,XT+
01800+
01810+                  3 X (-1) = -3
01820+
01830+                   4 X (-1) = -4
01840+
01850+                   7 X (-1) = -7
01860+
01870 01740 T                    10 X (-1) = -10
01880 T ASK THE INSTRUCTOR FOR HELP BEFORE YOU CONTINUE.
01890 T WHEN YOU ARE READY TO CONTINUE, PRESS THE RETURN BUTTON ONLY.
01900 L PCR
01910 01930 A (CR)
01920 01890 LQRY
01930 01940 L ICR
01940 T AT THIS TIME, I THINK YOU SHOULD TRY THE FOLLOWING EXERCISE.
01950 T
01960 N GOOD LUCK
01970 02000 CENT
01980 T NOW TYPE THE WORD SHALT.
01990 01980 LQRY
02000 TEXT+
02010+  FROM THIS MOMENT ON, WE WILL REFER TO A POSITIVE INTEGER AS POS
```

```
02020+AND A NEGATIVE INTEGER AS NEG.'
02030+  UNDER THE OPERATION OF MULTIPLICATION, THERE ARE FOUR
02040+POSSIBLE CASES TO CONSIDER.'  THEY ARE:
02050+
02060+      CASE   I%   POS X POS
02070+      CASE  II%   POS X NEG
02080+      CASE III%   NEG X POS
02090+      CASE  IV%   NEG X NEG
02100+
02110+ CAN YOU THINK OF ANOTHER CASE NOT INCLUDED IN THE ABOVE FOUR\
02120+
02130 02190 A' YES
02140 02290 A NO
02150 U
02160 T,YOU HAVE NOT ANSWERED THE QUESTION PROPERLY.'
02170 T CAN YOU THINK OF ANY OTHER CASES\\  TYPE YES OR NO.
02180 02130 T
02190 T "HAT IS YOUR NEW CASE\
02200 A
02210 T ISN"T THAT ALREADY INCLUDED AS ONE OF "Y FOUR CASES\\\\\\\
02220 T IF YOU STILL DON"T THINK SO.'.'.ASK THE TNSTRUCTOR FOR HELP.
02230 T WHEN YOU ARE READY TO CONTINUE, PRESS THE RETURN BUTTON.'.'
02240 L PCR
02250 02260 A (CR)
02260 L QRY
02270 02250 T "HEN YOU ARE READY TO CONTINUE,' PRESS THE RETURN BUTTON ON
Y.
02280 02290 L ICR
02290 TEXT+
02300+
02310+       CASE  I%   POS X POS
02320+
02330+
```

```
02340+      THIS IS THE CASE THAT YOU ARE ALREADY FAMILIAR WITH.
02350+ LET'S TAKE TWO POS INTEGERS,  SAY 6 AND 8
02360+  WE KNOW THAT      6 X 8 = 48
02370+ IN ANOTHER EXAMPLE, WE FIND THAT 3 X 7 = 21
02380+
02390+  THESE TWO EXAMPLES SHOW THAT  POS X POS = POS
02400+  THIS FACT IS NOT NEW TO YOU.
02410+
02420+       POS X POS = POS
02430+
02440 T DO YOU WANT MORE EXAMPLES\  TYPE YES OR NO.'.'
02450 T
02460 02510 02600 A YES
02470 02670 A NO
02480 U
02490 N ANSWER THE QUESTION.'.'
02500 02460 T DO YOU WANT MORE EXAMPLES\\\ TYPE YES OR NO.'
02510 T        6 X 4 = 24
02520 T      POS X POS = POS
02530 T
02540 T        3 X 5 = 15
02550 T      POS X POS = POS
02560 T
02570 T        2 X 20 = 40
02580 T      POS X POS = POS
02590 02440 T
02600 T ASK THE INSTRUCTOR FOR HELP BEFORE YOU CONTINUE.'
02610 T WHEN YOU ARE READY TO CONTINUE--PRESS THE RETURN BUTTON ONLY.'
02620 T
02630 L PCR
02640 02660 A (CR)
02650 02610 LQRY
```

```
02660 L ICR
02670 02700 OENT
02680 T TYPE THE WORD $HALT.
02690 02680 LORY
02700 TEXT+
02710+
02720+
02730+  CASE II% POS X NEG
02740+
02750+
02760+  SUPPOSE THAT YOU ARE ASKED TO MULITPLY  6 X (-5)
02770+ YOU ALREADY KNOW THAT   -5 = 5 X (-1)
02780+  THEREFORE.....6 X (-5) = 6 X 5 X (-1)
02790+                         =  30  X (-1)
02800+                         = -30
02810+  WE NOW KNOW THAT 6 X (-5) = -30
02820+ OR THAT          POS X NEG = NEG
02830+
02840+                  POS X NEG = NEG
02850+
02860+ NOTICE THAT THE MULTIPLICATION WAS CARRIED OUT IN TWO SETS.
02870+ FIRST MULTIPLY THE INTEGERS AS THOUGH BOTH WERE POSITIVE. THEN
02880+ USE THE PROPER RULE TO DECIDE UPON THE CORRECT SIGN.
02890+
02900+    FIRST.....MULTIPLY AS USUAL.
02910+    SECOND.....DECIDE ON THE PROPER SIGN.
02920+ THIS LAST EXAMPLE TELLS US THAT A POSITIVE INTEGER MULTIPLIED
02930+ BY A NEGATIVE INTEGER WILL YIELD A NEGATIVE PRODUCT.
02940+
02950+ NOW THAT YOU KNOW WHAT TO EXPECT, LET'S TRY ANOTHER EXAMPLE.
02960+
```

```
02970+     3 X (-2) = 3 X 2 X (-1)
02980+              =   6   X (-1)
02990+              =    -6
03000 T
03010 TEXT+
03020+
03030+  LET'S DO ANOTHER EXAMPLE---BETTER STILL---YOU TRY THE NEXT ONE
03040+  TYPE THE PRODUCT   11 X (-4)
03050 T
03060 03160 C -44
03070 03160 C (-44)
03080 03130 I 44
03090 03130 I +44
03100 03110 W
03110 T YOU'VE MULTIPLIED INCORRECTLY.  TRY AGAIN.
03120 03050 03150 T TYPE THE PRODUCT  11 X (-4)
03130 T YOU HAVE THE WRONG SIGN.  TRY AGAIN...
03140 03050 T TYPE THE PRODUCT 11 X (-4)
03150 03050 T ASK THE INSTRUCTOR TO SHOW YOU HOW TO MULTIPLY 11 X (-4)...
.
03160 0 GUD
03170 03200 Q ENT
03180 T TYPE THE WORD 'SHALT'.
03190 03180 L QRY
03200 TEXT+
03210+
03220+
03230+   CASE III%  NEG X POS
03240+
03250+  WE ALREADY KNOW TWO CASES:
03260+
```

```
03270+          CASE  I%  POS X POS = POS
03280+          CASE II%  POS X NEG = NEG
03290+
03300+   TO FIND THE PRODUCT OF A NEG X POS, WE WILL USE THE COMMUTATIVE

03310+ PROPERTY OF MULTIPLICATION.
03320+
03330+ RECALL THAT  6 X 5 = 5 X 6.  THIS IS AN EXAMPLE OF THE
03340+ COMMUTATIVE PROPERTY OF MULTIPLICATION.
03350+ WE'LL USE THIS IN A MOMEMT OR TWO.
03360+
03370+   TO FIND THE PRODUCT (-5) X 6...LET'S PROCEED AS FOLLOWS
03380+              (-5) X 6 = 6 X (-5)  BY THE COMMUTATIVE PROPERTY.
03390+       WE KNOW THAT 6 X (-5) = -30
03400+   COMBINING THESE TWO STATEMENTS, WE GET THAT
03410+           (-5) X 6 = -30
03420+           NEG  X POS = NEG
03430+   SO THE PRODUCT OF A NEGATIVE AND A POSITIVE IS NEGATIVE.
03440+
03450+         NEG X POS = NEG
03460+
03470+ LET'S DO ANOTHER EXAMPLE.  FOLLOW EACH STEP CAREFULLY
03480+     (-4) X 7 = 7 X (-4)
03490+                =   -28
03500+  SO (-4) X 7 =   -28
03510+
03520+   REMEMBER THAT***** NEG  X POS = NEG *****
03530 T TYPE THE PRODUCT    (-7) X 6
03540 03650 C -42
03550 03650 C (-42)
03560 03610 T 42
03570 03610 I +42
```

```
03580 03610 I (-42)
03590 03610 T (+42)
03600 03620 03640 U
03610 03530 T YOUR SIGN IS WRONG.  NOW TRY AGAIN.
03620 T THAT'S NOT RIGHT.  TRY AGAIN.
03630 03690 Q ENT
03640 03530 T ASK THE INSTRUCTOR TO SHOW YOU HOW TO FIND THE PRODUCT (-7
X 6
03650 O GUD
03660 03690 YENT
03670 T TYPE THE WORD SHALT.
03680 03670 LOOPY
03690 TEXT+
03700+
03710+  CASE IV% NEG X NEG
03720+
03730+
03740+  LET'S REVIEW WHAT YOU SHOULD KNOW BY NOW.
03750+        CASE   I% POS X POS = POS
03760+        CASE  II% POS X NEG = NEG
03770+        CASE III% NEG X POS = NEG
03780+        CASE  IV% NEG X NEG = \\\
03790+
03800+ TO COMPLETE THE ABOVE PATTERN, WHAT DO YOU THINK NEG X NEG SHOULD

03810+EQUAL\  TYPE WHICHEVER WORD YOU FEEL FITS BEST, POS OR NEG.
03820 03840 C POS.
03830 03860 W NEG
03840 O GUD
03850 03880 T REMEMBER THAT  NEG X NEG = POS
03860 N THAT'S NOT RIGHT
03870 03850 T THE CORRECT ANSWER IS POS
```

```
03880 TEXT+
03890+ LET"S LOOK AT SEVERAL EXAMPLES TO SEE HOW IT"S POSSIBLE THAT
03900+  NEG X NEG = POS
03910+
03920+  CONSIDER (-5) X (-6)
03930+ WE KNOW THAT  -6 = 6 X (-1)
03940+ SO (-5) X (-6)  =  (-5) X 6 X (-1)
03950+                 =    (-30)  X (-1)
03960+ DO YOU REMEMBER THE MULTIPLICATIVE PROPERTY OF -1 \\
03970+ THE PRODUCT OF ANY INTEGER AND -1 IS THE OPPOSITE OF THE INTEGER.'

03980+  THAT MEANS THAT  (-30) X (-1) EQUALS THE OPPOSITE OF -30.'
03990+AND
04000+THE OPPOSITE OF -30 IS +30.'
04010+        (-30) X (-1) = 30
04020+ THIS GIVES US    (-5) X (-6) = (-5) X 6 X (-1)
04030+                              =    (-30) X (-1)
04040+                              =          30
04050+                  (-5) X (-6) =          30
04060+                   NEG X NEG = POS
04070+
04080+ HERE"S ANOTHER EXAMPLE.  WATCH EACH STEP VERY CAREFULLY.'
04090+  (-8) X (-2) = (-8) X 2 X (-1)
04100+              =   (-16)  X (-1)
04110+              =         16
04120+  (-8) X (-2) =         16
04130+AGAIN        NEG X NEG = POS
04140+  TYPE THE PRODUCT (-4) X (-3)
04150 04240 C 12
04160 04240 C +12
04170 04200 04220 I -12
04180 04200 04220 I (-12)
04190 04210 04220 W
```

```
04200 04150 N, THE SIGN IS INCORRECT. TYPE THE PRODUCT (-4) X (-3)
04210 04150 THAT'S INCORRECT.  TYPE THE PRODUCT (-4) X (-3)
04220 T ASK THE INSTRUCTOR FOR HELP BEFORE YOU CONTINUE.
04230 04150 T THEN TYPE THE PRODUCT   (-4) X (-3)
04240 C GUD
04250 04280 G ENT
04260 T TYPE THE WORD $HALT.
04270 04260 LOOPY
04280 TEXT+
04290+ NOW YOU'LL HAVE AN OPPORTUNITY TO PRACTICE ALL THAT YOU'VE LEARN
.
04300+
04310+       BEFORE YOU BEGIN THE TEST HOWEVER, LET'S REVIEW WHAT YOU
04320+ SHOULD HAVE LEARNED.
04330+
04340+ WHEN YOU MULTIPLY INTEGERS, YOU CARRY OUT THE MULTIPLICATION
04350+ IN TWO STEPS.
04360+ FIRST.....DISREGARD THE SIGNS AND MULTIPLY AS USUAL.
04370+SECOND.....FIND THE CORRECT SIGN FOR THE PRODUCT USING THE RULES%

04380+
04390+         POS X POS = POS
04400+         POS X NEG = NEG
04410+         NEG X POS = NEG
04420+         NEG X NEG = POS
04430+
04440+GOOD LUCK.....
04450 DTMI V50
04460 VLDV V60=V50-V40
04470 VLDV V70=V60/60
04480 04510 GENT
04490 T TYPE THE WORD $HALT.
```

```
04500 04490 LQRY
04510 V RXD 1,V30
04520 T WELCOME BACK FROM THE TEST.
04530 V DIS V30,(*YOUR SCORE ON TEN IS*,I2,*.*)
04540 VDIS V70,(* THE TIME TAKEN FOR THE LESSON IS *,I3,* MINUTES.*)
04550 04600 V CMP V30.GE.8
04560 T  YOU SHOULD HAVE RATNED A HIGHER SCORE.
04570 T  TAKE THE LESSON AGAIN AT ANOTHER TIME.
04580 N GOODBYE UNTIL THE NEXT TIME
04590 04630 G
04600 T CONGRATULATIONS ON YOUR ACCOMPLISHMENT....YOU HAVE
04610 T SUCCESSFULLY COMPLETED THIS LESSON.
04620 N GOODBYE FOR NOW
04630 E
```

```
00100 N HELLO
00110* PROGRAM INQR
00120* THIS PROGRAM USES A TUTORIAL STRATEGY
00130* TO TEACH THE RULES OF SIGNS FOR THE
00140* MULTIPLICATION OF INTEGERS.
00150 TEXT+
00160+        WELCOME TO A COMPUTER ASSISTED ALGEBRA LESSON.  SINCE
00170+ THIS IS THE FIRST TIME THAT YOU ARE SITTING AT A COMPUTER
00180+ TERMINAL, HERE ARE SOME BASIC INSTRUCTIONS YOU MUST ALWAYS
00190+ REMEMBER%
00200+
00210+        -WAIT FOR A QUESTION MARK (\) BEFORE YOU TYPE AN ANSWER.
00220+        -AFTER EVERY ANSWER YOU TYPE, PRESS THE RETURN BUTTON.
00230+         IF YOU CAN'T FIND THE RETURN BUTTON, ASK THE
00240+         INSTRUCTOR FOR HELP.
00250+        -THE NUMBER ZERO WILL BE TYPED AS 0.
00260+        -THE LETTER OH WILL BE TYPED AS O.
00270+        -WHENEVER YOU TYPE A NUMBER, TYPE THE NUMERAL.
00280+         IE, TYPE 10 FOR TEN.
00290+        -IF YOU MAKE AN ERROR, PRESS THE BUTTON MARKED #ESC#
00300+         AND RETYPE THE ENTIRE ANSWER.
00310 N NOW LET'S BEGIN.  GOOD LUCK
00320 TEXT+
00330+
00340+        IN ORDER THAT I WILL BE ABLE TO TEACH THIS LESSON
00350+ PROPERLY, I MUST KNOW WHAT YOU ALREADY UNDERSTAND.  HELP ME
00360+ BY TRYING THE FOLLOWING QUIZ.
00370+
00380+
00390+ SIMPLIFY THE FOLLOWING%
```

```
00400+ TYPE THE ANSWER ONLY. MAKE SURE YOU TYPE THE SIGN IF THE NUMBER
00410+ IS NEGATIVE AND REMEMBER TO PRESS THE RETURN BUTTON.
00420+      (-7) + (-11) =
00430 U R
00440 V CLR
00450 00480 C -18
00460 00480 C (-18)
00470 00490 W
00480 V LDV V1=V1+1
00490 T       28 + (-9) =
00500 00530 C 19
00510 00530 C +19
00520 00540 W
00530 V LDV V1=V1+1
00540 T       (-17) + 6 =
00550 00580 C -11
00560 00580 C (-11)
00570 00590 W
00580 V LDV V1=V1+1
00590 T TYPE THE OPPOSITE OF -6.
00600 00640 C 6
00610 00640 C +6
00620 W
00630 00650 T NO, THE OPPOSITE OF -6 IS 6.
00640 V LDV V1=V1+1
00650 T TYPE THE OPPOSITE OF 4.
00660 00690 C -4
00670 00690 C (-4)
00680 00700 W
00690 V LDV V1=V1+1
00700 00760 V CMP V1.GE.4
00710 T
```

```
00720 TEXT+
00730+       I'M VERY SORRY BUT YOU ARE NOT YET READY FOR THIS LESSON.
00740+ GOODBYE FOR NOW.
00750 07#40 G
00760 T GOOD.  YOU WILL BE ABLE TO FOLLOW THE LESSON.
00770 T
00780 T NOW, TYPE THE FOLLOWING PRODUCTS%
00790 T      (-4) X 2 =
00800 00830 C -8
00810 00830 C (-8)
00820 01110 W
00830 T    (-5) X 20 =
00840 00870 C -100
00850 00870 C (-100)
00860 01110 W
00870 T     3 X (-5) =
00880 00910 C -15
00890 00910 C (-15)
00900 01110 W
00910 T  6 X (-10)
00920 00950 C -60
00930 00950 C (-60)
00940 01110 W
00950 T  (-3) X (-4) =
00960 01010 C 12
00970 01010 C +12
00980 01010 C (12)
00990 01010 C (+12)
01000 01110 W
01010 T    (-5) X (#5) =
```

```
01020 01070 C 25
01030 01070 C ±25
01040 01070 C (25)
01050 01070 C (+25)
01060 01110 W
01070 T YOU KNOW ALL THE MATERIAL THAT THIS LESSON COULD POSSIBLY
01080 H TEACH YOU.  SO-I'LL SEND YOU ON YOUR WAY.
01090 T GOODBYE FOR NOW.
01100 07140 G
01110 OTMI V40
01120 TEXT+
01130+
01140+ THE PURPOSE OF THIS LESSON IS TO TEACH THE MULTIPLICATION
01150+ OF INTEGERS.  AFTER YOU HAVE COMPLETED THIS LESSON, YOU WILL
01160+ BE ABLE TO CORRECTLY IDENTIFY THE PRODUCTS IN THE SECTION
01170+ YOU JUST TRIED.
01180+
01190+
01200+ BEFORE WE CAN DISCUSS MULTIPLICATION, WE NEED TO REVIEW
01210+ SOME BASIC PRINCIPLES.
01220+
01230+
01240+ TYPE THE PRODUCT
01250+
01260+      3 X (-1) =
01270+
01280 01490 C -3
01290 01490 C (-3)
01300 01330 I  3
01310 01330 I +3
01320 01330 W
```

```
01330 N THAT'S NOT RIGHT.
01340 TEXT+
01350+
01360+ RECALL THAT WE CAN EXPAND  4 X 5  INTO  5 + 5 + 5 + 5
01370+
01380+  OR    4 X 5 = 5 + 5 + 5 + 5
01390+
01400+
01410+ IT FOLLOWS THAT  3 X (-1) = (-1) + (-1) +(-1)
01420+
01430+ WE NOW KNOW HOW TO ADD  (-1) + (-1) + (-1) = -3
01440+
01450+ COMBINING THESE TWO FACTS WE ARRIVE AT  3 X (-1) = -3
01460+
01470+ WE WILL USE THIS FACT IN A MOMENT.  REMEMBER IT.
01480 01500 G
01490 OGUO
01500 TEXT+
01510+
01520+ TYPE THE PRODUCT
01530+
01540+      5 X (-1) =
01550+
01560 01860 C -5
01570 01860 C (-5)
01580 01610 I 5
01590 01610 I +5
01600 01610 W
01610 N NO, THAT'S NOT RIGHT.
01620 TEXT+
01630+
```

```
01640+ THE EXPANSION FOR  5 X (-1) IS  (-1)+ (-1) + (-1) + (-1) + (-1)
01650+
01660+ THIS GIVES US  5 X (-1) = -5
01670+
01680+ IF THIS ISN"T TOO CLEAR, STOP AND THINK ABOUT IT.
01690 T WHEN YOU ARE READY TO CONTINUE PRESS THE RETURN BUTTON.
01700 T IF YOU CAN"T UNDERSTAND THE LAST STATEMENT TYPE "HELP".
01710 L PCR
01720 01760 A HELP
01730 01760 A "HELP"
01740 01850 A (CR)
01750 01690 LQRY
01760 TEXT+
01770+ WE HAVE   5 X (-1) = (-1) + (-1) + (-1) + (-1) + (-1)
01780+
01790+ YOU SHOULD KNOW THAT (-1) + (-1) + (-1) + (-1) + (-1) = -5
01800+
01810+ COMBINING THESE TWO FACTS, WE ARRIVE AT
01820+
01830+       5 X (-1) = -5
01840+
01850 01870 G
01860 OGUD
01870 TEXT+
01880+
01890+ USING THE ABOVE EXAMPLES AS A BASIS,  IS THE FOLLOWING
01900+ TRUE OR FALSE
01910+
01920+ "THE PRODUCT OF ANY INTEGER AND (-1) IS THE OPPOSITE
01930+  OF THE INTEGER."
01940+
```

```
01950 T TYPE EITHER TRUE OR FALSE
01960 T
01970 02000 C TRUE
01980 02020 I FALSE
01990 02010 W
02000 02400 O GUD
02010 01950 L QRY
02020 O BAD
02030 TEXT+
02040+ WE SAW THAT  3 X (-1) = -3
02050+ AND THAT  5 X (-1) = -5
02060+
02070+ SIMILARLY  2 X (-1) = -2
02080+ AND        7 X (-1) = -7
02090+ AND        6 X (-1) = -6
02100+
02110+ THIS SUGGESTS THAT THE PRODUCT OF ANY INTEGER AND (-1)
02120+ IS THE OPPOSITE OF THE INTEGER.
02130+ REMEMBER THIS.  WE WILL BE USING THIS LATER IN THE LESSON.
02140+
02150+ WOULD YOU LIKE MORE EXAMPLES\
02160 N TYPE YES OR NO
02170 02400 A NO
02180 02210 02340 A YES
02190 U
02200 02170 N ANSWER THE QUESTION...  WOULD YOU LIKE MORE EXAMPLES...
02210 TEXT+
02220+
02230+  4 X (-1) = -4
02240+
02250+  8 X (-1) = -4
02260+
```

```
02270+  7 X (-1) = -7
02280+
02290 02150 T 10 X (-1) = -10
02300 T WHEN YOU ARE READY TO CONTINUE PRESS THE RETURN BUTTON ONLY.
02310 L PCR
02320 02390 A (CR)
02330 02300 L QRY
02340 T ASK THE INSTRUCTOR FOR HELP BEFORE YOU CONTINUE.
02350 T WHEN YOU ARE READY TO CONTINUE PRESS THE RETURN BUTTON ONLY.
02360 L PCR
02370 02390 A (CR)
02380 02350 L QRY
02390 L ICR
02400 TEXT+
02410+
02420+ AT THIS TIME, I THINK YOU SHOULD TRY THE FOLLOWING EXERCISE.
02430+
02440 N GOOD LUCK.
02450 02480 Q ENT
02460 T NOW TYPE THE WORD $HALT.
02470 02460 L QRY
02480 N WELCOME BACK FROM THE EXERCISE
02490 TEXT+
02500+ FROM THIS MOMENT ON, WE WILL REFER TO POSITIVE INTEGER AS POS
02510+ AND A NEGATIVE INTEGER AS NEG.
02520 T TYPE THE PRODUCT
02530 T
02540 T    6 X 8 =
02550 T
02560 02620C 48
02570 02620C +48
02580 02600I -48
```

```
02590 02610W
02600 02520 T YOUR SIGN IS WRONG.  TRY AGAIN.
02610 02520 L QRY
02620 0 GUD
02630 T NOW TYPE THE PRODUCT
02640 T   3X7 =
02650 T
02660 02730 C 21
02670 02730 C +21
02680 02700 I -21
02690 02720 W
02700 T YOUR SIGN IS WRONG.  TRY AGAIN.
02710 02640 T TYPE THE PRODUCT
02720 02710 L QRY
02730 0 GUD
02740 T USING THE ABOVE EXAMPLES AS A BASIS COMPLETE THE FOLLOWING.
02750 T
02760 T    POS X POS =---
02770 T
02780 T TYPE POS OR NEG
02790 03280 C POS
02800 02830 I NEG
02810 W
02820 02760 L QRY
02830 T
02840 0 BAD
02850 T LET'S LOOK AT MORE EXAMPLES.
02860 T WE KNOW      6 X4 = 24
02870 T OR         POS X POS = POS
02880 T
02890 T AGAIN     3 X S = 15
02900 T OR      POS X POS = POS
```

```
02910 T
02920 T DO YOU WANT MORE EXAMPLES    TYPE YES OR NO.
02930 03140 C NO
02940 02970 C YES
02950 W
02960 02920 L QRY
02970 T    6 X 2 = 12
02980 T  POS X POS = POS
02990 T
03000 T    5 X 8 = 40
03010 T POS X POS = POS
03020 T
03030 T DO YOU WANT MORE EXAMPLES    TYPE YES OR NO.
03040 03080 C YES
03050 03140 C NO
03060 W
03070 03030 L QRY
03080 T ASK THE INSTRUCTOR FOR HELP.
03090 T WHEN YOU ARE READY TO CONTINUE,  PRESS THE RETURN BUTTON ONLY.
03100 L PCR
03110 03130 A (CR)
03120 03090 I QRY
03130       L ICR
03140 T
03150 T COMPLETE THE FOLLOWING.  TYPE POS OR NEG.
03160 T
03170 T     POS X POS =---
03180 03280 C POS
03190 03220 I NEG
03200 W
03210 03150 L QRY
03220 T ASK THE INSTRUCTOR FOR HELP.
```

```
03230 T WHEN YOU ARE READY TO CONTINUE, PRESS THE RETURN BUTTON ONLY.
03240 L PCR
03250 03270 A (CR)
03260 03230       L QRY
03270       L ICR
03280 O GUD
03290 N NOW TRY ANOTHER EXERCISE
03300 T
03310 03350 GEN T
03320 T TYPE THE WORD $HALT.
03330 T
03340 03320 L QRY
03350 TEXT+
03360+
03370+
03380+ WELCOME BACK FROM THE EXERCISE.
03390+
03400 T TYPE THE PRODUCT
03410 T
03420 T [illegible]5) =
03430 03620 C -30
03440 03620 C (-30)
03450 03490 I 30
03460 03490 I +30
03470       W
03480 03400 L QRY
03490 T
03500 T THAT'S NOT QUITE RIGHT.
03510 T TO CORRECTLY MULTIPLY  6 X (-5) =
03520 T WE ALREADY KNOW THAT -5 = 5 X (-1)
03530 T THEREFORE..... 6 X (-5) = 6 X 5 X (-1)
03540 T                          =    30 X (-1)
```

```
03550 T                          =   -30
03560 T
03570 T WE NOW KNOW THAT 6 X (-5) = -30
03580 T
03590 N LET'S TRY ANOTHER ONE.
03600 T
03610 03630 G
03620 O GUD
03630 T
03640 T TYPE THE PRODUCT
03650 T   3 X (-2) =
03660 T
03670 03960 C -6
03680 03960 C (-6)
03690 03730 I S
03700 03730 I +6
03710 W
03720 03630 LORY
03730 T
03740 T THAT'S NOT RIGHT.
03750 T WE SAW EARLIER THAT (-2) = 2 X (-1)
03760 T THEREFORE.... 3 X (-2) = 3 X 2 X (-1)
03770 T WHICH GIVES US          =   6   X (-1)
03780 T                         =  -6
03790 T  AGAIN          3 X (-2) =  -6
03800 T
03810 T LET'S DO ANOTHER EXAMPLE---BETTER STILL---YOU TRY THE NEXT ONE.
03820 T
03830 T TYPE THE PRODUCT
03840 T     11 X (-4) =
03850 T
```

```
03860 03960 C -44
03870 03960 C (-44)
03880 03920 I 44
03890 03920 I +44
03900 W
03910 03830 L QRY
03920 T
03930 T ASK THE INSTRUCTOR TO SHOW YOU HOW TO MULTIPY 11X (-4) =
03940 T   TYPE THE PRODUCT 11 X (-4) =
03950 03850 G
03960 O GUD
03970 T
03980 T COMPLETE THE FOLLOWING.  TYPE POS OR NEG.
03990 T
04000 T     POS X NEG =---
04010 T
04020 T
04030 04520 C NEG
04040 04070 I POS
04050 W
04060 03980 L QRY
04070 T
04080 O BAD
04090 T LET'S LOOK AT MORE EXAMPLES.
04100 T WE KNOW    6 X (-4) = -24
04110 T OR         POS X NEG = NEG
04120 T
04130 T AGAIN      3 X (-5) = -15
04140 T OR         POS X NEG = NEG
04150 T
04160 T DO YOU WANT MORE EXAMPLES    TYPE YES OR NO.
04170 04380 C NO
04180 04210 C YES
```

```
04190 W
04200 04160 LQRY
04210 T    6 X (-2) = -12
04220 T   POSX NEG  = NEG
04230 T
04240 T    5 X (-8) = -40
04250 T    POS X NEG= NEG
04260 T
04270 T DO YOU WANT MORE EXAMPLES    TYPE YES OR NO.
04280 04320 C YES
04290 04360 C NO
04300 W
04310 04270 LQRY
04320 T ASK THE INSTRUCTOR FOR HELP.
04330 T WHEN YOU ARE READY TO CONTINUE, PRESS THE RETURN BUTTON ONLY.
04340 L PCR
04350 04370 A (CR)
04360 04330 LQRY
04370 L ICR
04380 T
04390 T COMPLETE THE FOLLOWING.   TYPE POS OR NEG.
04400 T
04410 T    POS X NEG =---
04420 04520 C NEG
04430 04460 T POS
04440 W
04450 04390 LQRY
04460 T ASK THE INSTRUCTOR FOR HELP.
04470 T WHEN YOU ARE READY TO CONTINUE, PRESS THE RETURN BUTTON ONLY.
04480 L PCR
04490 04510 A (CR)
```

```
04500 04470 LQRY
04510 L ICR
04520 O GUD
04530 N NOW TRY ANOTHER EXERCISE
04540 T
04550 04590 QENT
04560 T TYPE THE WORD $HALT.
04570 T
04580 04560 LQRY
04590 T
04600 N WELCOME BACK FROM THE EXERCISE
04610 N LET'S TRY ANOTHER CASE
04620 T
04630 T TYPE THE PRODUCT
04640 T
04650 T      (-5) X 6 =
04660 04840 C -30
04670 04640 C (-30)
04680 04720 I 30
04690 04720 I -30
04700 W
04710 04630 LQRY
04720 OBAD
04730 T RECALL THAT  6 X 5 = 5 X 6.  THIS EXAMPLE OF THE
04740 T COMMUTATIVE PROPERTY WILL BE USED IN A MOMENT.
04750 T
04760 T TO FIND THE PRODUCT (-5) X 6 ...LET'S PROCEED AS FOLLOWS.
04770 T      (-5) X 6 = 6 X (-5)   BY THE COMMUTATIVE PROPERTY.
04780 T WE KNOW THAT  6 X (-5) = -30
04790 T COMBINING THESE TWO STATEMENTS, WE GET
04800 T
```

```
04810 T      (-5) X 6 = -30
04820 T
04830 04850 G
04840 O GUD
04850 N TYPE THE PRODUCT
04860 T
04870 T      (-4) X 7 =
04880 T
04890 05050 C -28
04900 05050 C (-28)
04910 04950 I 28
04920 04960 I +28
04930 W
04940 04850 LORY
04950 04850 04960 N YOU HAVE THE WRONG SIGN
04960 T LET'S WORK THE EXAMPLE SLOWLY.
04970 T
04980 T BY THE COMMUTATIVE PROPERTY  (-4) X 7 = 7 X (-4)
04990 T SO     (-4) X 7 = 7 X (-4)
05000 T                 =  -28
05010 T THEREFORE...
05020 T       (-4) X 7 =  -28
05030 T
05040 05060 G
05050 O GUD
05060 T
05070 T USING THE ABOVE EXAMPLES AS A BASIS COMPLETE THE FOLLOWING.
05080 T
05090 T    NEG X POS = ---
05100 T
05110 T TYPE POS OR NEG
```

```
05120 05610 C NEG
05130 05160 T POS
05140 W
05150 05090 L QRY
05160 T
05170 O BAD
05180 T LET'S LOOK AT MORE EXAMPLES.
05190 T WE KNOW (-6) X 4 = -24
05200 T OR      NEG X POS = NEG
05210 T
05220 T AGAIN     (-3) X 5 = -15
05230 T OR        NEG X POS = NEG
05240 T
05250 T DO YOU WANT MORE EXAMPLES     TYPE YES OR NO.
05260 05470 C NO
05270 05300 C YES
05280 W
05290 05250 L QRY
05300 T    (-4) X 3 = -12
05310 T    NEG X POS = NEG
05320 T
05330 T    (-3) X 6 = -18
05340 T    NEG X POS = NEG
05350 T
05360 T DO YOU WANT MORE EXAMPLES     TYPE YES OR NO.
05370 05410 C YES
05380 05470 C NO
05390 W
05400 05360 L QRY
05410 T ASK THE INSTRUCTOR FOR HELP.
05420 T WHEN YOU ARE READY TO CONTINUE PRESS, THE RETURN BUTTON ONLY.
```

```
05430 L PCR
05440 05460 A (CR)
05450 05420 LQRY
05460 L ICR
05470 T
05480 T COMPLETE THE FOLLOWING.  TYPE POS OR NEG.
05490 T
05500 T     NEG X POS = ---
05510 05610 C NEG
05520 05550 C POS
05530 W
05540 05580 LQRY
05550 T ASK THE INSTRUCTOR FOR HELP.
05560 T WHEN YOU ARE READY TO CONTINUE PRESS THE RETURN BUTTON ONLY.
05570 L PCR
05580 05600 A (CR)
05590 05560 LQRY
05600 LICR
05610 N GUD
05620 N NOW TRY ANOTHER EXERCISE
05630 T
05640 05680 CENT
05650 T TYPE THE WORD SHALT.
05660 T
05670 05650 LQRY
05680 N WELCOME BACK FROM THE EXERCISE
05690 T NOW TYPE THE PRODUCT
05700 T    (-5) X (-6) =
05710 T
05720 05950 C 30
05730 05950 C +30
```

```
05740 05780 I -30
05750 05780 I (-30)
05760 W
05770 05700 LQRY
05780 T THAT'S NOT RIGHT.
05790 T LET'S EXAMINE THIS EXAMPLE CAREFULLY.
05800 T
05810 T WE KNOW THAT -6 = 6 X (-1)
05820 T SO  (-6) X (-6) = (-5) X 6 X (-1)
05830 T                 =    (-30) X (-1)
05840 T
05850 T DO YOU REMEMBER THE MULTIPLICATIVE PROPERTY OF -1
05860 T THE PRODUCT OF ANY INTEGER AND -1 IS THE OPPOSITE OF THE INTEGER.

05870 T THAT MEANS THAT  (-30) X (-1) EQUALS THE OPPOSITE OF -30.
05880 T AND
05890 T THE OPPOSITE OF -30 IS +30.
05900 T
05910 T THIS GIVES US   (-6) X (-6) = (-5) X 6 X (-1)
05920 T                             =    (-30) X (-1)
05930 T                             =      +30
05940 05960 G
05950 OGUD
05960 T
05970 T NOW TYPE THE PRODUCT
05980 T     (-8) X (-2) =
05990 06150 C 16
06000 06150 C +16
06010 06050 06070 I (-16)
06020 06050 06070 I (-16)
06030 W
06040 05980 LQRY
```

```
06050 03AD
06060 05980 T YOUR SIGN IS WRONG.  TRY AGAIN.
06070 T YOUR SIGN TS WRONG.  LET'S WORK THE EXAMPLE SLOWLY.
06080 T WATCH EACH STEP CAREFULLY.
06090 T
06100 T     (-8) X (-2) = (-8) X 2 X (-1)
06110 T                 =    (-16) X (-1)
06120 T                 =     +16
06130 T
06140 06160 G
06150 0 GUD
06160 T
06170 T USING THE ABOVE EXAMPLES AS A BASIS COMPLETE THE FOLLOWING.
06180 T
06190 T    NEG X NEG = ---
06200 T
06210 T TYPE POS OR NEG
06220 06710 C POS
06230 06260 T NEG
06240 W
06250 06190 I SRY
06260 T
06270 0 BAD
06280 T LET'S LOOK AT MORE EXAMPLES.
06290 T WE KNOW  (-6) X (-4) = 24
06300 T  OR      NEG  X NEG  = POS
06310 T
06320 T AGAIN    (-3) X (-5) = 15
06330 T OR       NEG  X NEG  = POS
06340 T
06350 T DO YOU WANT MORE EXAMPLES     TYPE YES OR NO.
```

```
06360 06570 C NO
06370 06400 C YES
06380 W
06390 06350 LQRY
06400 T    (-5) X (-4) = 20
06410 T    NEG X NEG = POS
06420 T
06430 T    (-4) X (-8) = 32
06440 T    NEG X NEG = POS
06450 T
06460 T DO YOU WANT MORE EXAMPLES  TYPE YES OR NO.
06470 06510 C YES
06480 06570 C NO
06490 W
06500 06460 LQRY
06510 T ASK THE INSTRUCTOR FOR HELP.
06520 T WHEN YOU ARE READY TO CONTINUE PRESS THE RETURN BUTTON ONLY.
06530 L PCR
06540 06560 A (CR)
06550 06520 LQRY
06560 L ICR
06570 T
06580 T COMPLETE THE FOLLOWING.  TYPE POS OR NEG.
06590 T
06600 T    NEG X NEG = ---
06610 06710 C POS
06620 06650 I NEG
06630 W
06640 06580 LQRY
06650 T ASK THE INSTRUCTOR FOR HELP.
06660 T WHEN YOU ARE READY TO CONTINUE PRESS THE RETURN BUTTON ONLY.
```

```
06670 L PCR
06680 06700 A (CR)
06690 06660 LQRY
06700 L ICR
06710 N GUD
06720 N NOW TRY ANOTHER EXERCISE.
06730 T
06740 06780 QENT
06750 T TYPE THE WORD $HALT.
06760 T
06770 06750 LQBY
06780 TEXT+
06790+
06800+ NOW YOU'LL HAVE AN OPPORTUNITY TO PRACTICE ALL THAT YOU'VE LEARNED.

06810+
06820+ BEFORE YOU BEGIN THE TEST HOWEVER, LET'S REVIEW WHAT YOU
06830+ SHOULD HAVE LEARNED.
06840+
06850+ WHEN YOU MULTIPLY INTEGERS, YOU CARRY OUT THE MULTIPLICATION
06860+ IN TWO STEPS.
06870+ FIRST.....DISREGARD THE SIGNS AND MULTIPLY AS USUAL.
06880+ SECOND....FIND THE CORRECT FOR THE PRODUCT USING THE RULES
06890+
06900+        POS X POS = POS
06910+        POS X NEG = NEG
06920+        NEG X POS = NEG
06930+        NEG X NEG = POS
06940+
06950 N GOOD LUCK
06960 NTMI V60
```

```
06970 VLDV V60=V50-V40
06980 VLDV V70=V60/60
06990 07020 GENT
07000 T TYPE THE WORD $HALT.
07010 07000 L QRY
07020 V RXD 1,V30
07030 T WELCOME BACK FROM THE TEST.
07040 V DIS V30,(*YOUR SCORE ON TEN IS*,I2,*.*)
07050 VDIS V70,(* THE TIME TAKEN FOR THE LESSON IS *,I3,* MINUTES.*)
07060 07110 VCMP V30.GE.8
07070 T YOU SHOULD HAVE GAINED A HIGHER SCORE.
07080 T TAKE THE LESSON AGAIN AT ANOTHER TIME.
07090 N GOODBYE UNTIL THE NEXT TIME
07100 07140 G
07110 T CONGRATULATIONS ON YOUR ACCOMPLISHMENT...YOU HAVE
07120 T SUCCESSFULLY COMPLETED THIS LESSON.
07130 N GOODBYE FOR NOW
07140 E
```

Appendix 4

```
00100 PROGRAM XR1(INPUT,OUTPUT)
00110 PRINT,*TYPE THE FOLLOWING PRODUCTS*
00120 1 IRIGHT=IWRONG=0
00130 10 I=RANF(0)*100
00140 11 PRINT 20,I
00150 20 FORMAT(1X,I2,*   X (-1) =*)
00160 READ,INPT
00170 IF(INPT.GT.0)GOTO 100
00180 J=-I
00190 IF(J.EQ.INPT)GOTO 200
00200 IWRONG=IWRONG+1
00210 PRINT,*YOU ARE WRONG*
00220 IF(IWRONG.GE.5)GOTO 50
00230 PRINT,*LET'S TRY IT AGAIN...*
00240 GOTO 11
00250 50 PRINT,*ASK YOUR INSTRUCTOR FOR HELP...*
00260 GOTO 1
00270 100 PRINT,*YOU HAVE TYPED THE WRONG SIGN. TRY AGAIN*
00280 GOTO 11
00290 200 IRIGHT=IRIGHT+1
00300 IF(IRIGHT.GT.4)GOTO 2000
00310 PRINT,*THAT'S RIGHT... LET'S TRY ANOTHER*
00320 GOTO 10
00330 2000 PRINT,*YOU HAVE SUCCESSFULLY COMPLETED THE EXERCISE*
00340 PRINT,*CONGRATULATIONS*
00350 END
```

Appendix 5

```
00100 PROGRAM EXR2 (INPUT,OUTPUT)
00110 IRIGHT=IWRONG=0
00120 PRINT,*TYPE THE FOLLOWING PRODUCTS*
00130 GOTO 50
00140 45 PRINT,*THAT'S IT,HERE COMES ANOTHER ONE.....*
00150 50 INT1=RANF(0)*10+2
00160 INT2=RANF(0)*10+2
00170 60 PRINT 65,INT1,INT2
00180 65 FORMAT (2X,I2,*  X *,I2)
00190 K=INT1*INT2
00200 READ,INPT
00210 IF (K.EQ.INPT)GOTO 170
00220 IWRONG=IWRONG+1
00230 IF (IWRONG.EQ.5)GOTO 150
00240 PRINT,*THAT'S NOT RIGHT,TRY AGAIN.*
00250 GOTO60
00260 150 PRINT,*ASK THE INSTRUCTOR FOR HELP AND BEGIN AGAIN.....*
00270 IRIGHT=IWRONG=0
00280 170 IF (IRIGHT.EQ.5)GO TO 200
00290 IRIGHT=IRIGHT+1
00300 GOTO45
00310 200 PRINT,*CONGRATULATIONS,YOU HAVE SUCCESSFULLY COMPLETED THIS*
00320 PRINT,*PART OF THE EXERCISE.*
00330 STOP
00340 END
```

Appendix 6

```
00100 PROGRAM EXR3 (INPUT,OUTPUT)
00110 IRIGHT=IWRONG=0
00120 PRINT,*TYPE THE FOLLOWING PRODUCTS.*.*
00130 GOTO50
00140 45 PRINT,*THAT"S IT, HERE"S ANOTHER ONE.*.*
00150 50 INT1=RANF(0)*10+3
00160 INT2=RANF(0)*10+3
00170 60 PRINT 65,INT1,INT2
00180 65 FORMAT (2X,I2,*  X (-*,I2,*)*)
00190 K=INT1*INT2*(-1)
00200 READ,INPT
00210 IF(K.EQ.INPT)GOTO170
00220 IWRONG=IWRONG+1
00230 IF (IWRONG.EQ.5)GOTO150
00240 PRINT,*THAT"S NOT RIGHT,TRY IT ONE MORE TIME.*.*
00250 GOTO60
00260 150 PRINT,*ASK THE INSTRUCTOR FOR HELP AND BEGIN AGAIN.*.*
00270 IRIGHT=IWRONG=0
00280 170 IF(IRIGHT.EQ.5)GOTO200
00290 IRIGHT=IRIGHT+1
00300 GOTO45
00310 200 PRINT,*CONGRATULATIONS, YOU HAVE SUCCESSFULLY COMPLETED THIS*

00320 PRINT,*PART OF THE EXERCISE.*
00330 STOP
00340 END
```

Appendix 7

```
00100 PROGRAM EXR4 (INPUT,OUTPUT)
00110 IRIGHT=IWRONG=0
00120 PRINT,*TYPE THE FOLLOWING PRODUCTS.*.*
00130 GOTO50
00140 45 PRINT,*THAT'S RIGHT.  NOW TRY THIS ONE.*.*
00150 50 INT1=RANF(0)*10 +4
00160 INT2=RANF(0)*10+4
00170 60 PRINT 65,INT1,INT2
00180 65 FORMAT (2X,* (-*,I2,*) X *,I2)
00190 K=INT1*INT2*(-1)
00200 READ,INPT
00210 IF(K.EQ.INPT)GOTO170
00220 IWRONG=IWRONG+1
00230 IF (IWRONG.EQ.5)GOTO150
00240 PRINT,*THAT'S NOT RIGHT,TRY IT AGAIN.*.*
00250 GOTO60
00260 150 PRINT,*ASK THE INSTRUCTOR FOR HELP AND BEGIN AGAIN.*.*
00270 IRIGHT=IWRONG=0
00280 170 IF(IRIGHT.EQ.5)GOTO200
00290 IRIGHT=IRIGHT+1
00300 GOTO45
00310 200 PRINT,*CONGRATULATIONS,YOU HAVE SUCCESSFULLY PASSED THIS EXERC
SE.*
00320 STOP
00330 END
```

Appendix 8

```
00100 PROGRAM EXRS (INPUT,OUTPUT)
00110 20 IRIGHT=IWRONG=0
00120 PRINT,*TYPE THE FOLLOWING PRODUCTS.*.*
00130 GO TO 50
00140 45 PRINT,*THAT"S RIGHT, HERE"S ANOTHER ONE.*.*
00150 50 INT1=RANF(0)*10+5
00160 INT2=RANF(0)*10+5
00170 60 PRINT 65,INT1,INT2
00180 65 FORMAT (2X,* ( -*,I2,*) X (-*,I2,*)*)
00190 K=INT1*INT2
00200 READ,INPT
00210 IF (K.EQ.INPT)GOTO170
00220 IWRONG=IWRONG+1
00230 IF(IWRONG.EQ.5)GOTO150
00240 PRINT,*THAT"S NOT RIGHT,TRY AGAIN.*.*
00250 GOTO60
00260 150 PRINT,*ASK THE INSTRUCTOR FOR HELP.*.*
00270 GO TO 20
00280 170 IRIGHT=IRIGHT+1
00290 IF(IRIGHT.EQ.5)GOTO200
00300 GO TO 45
00310 200 PRINT,*CONGRATULATION'S, YOU HAVE SUCCESSFULLY COMPLETED THIS E
ECISE*
00320 STOP
00330 END
```

Appendix 9

```
00100 PROGRAM EXERTST (INPUT,OUTPUT,TAPE6)
00110 IRIGHT=0
00120 PRINT,*TYPE THE FOLLOWING PRODUCTS*
00130 DO 200 I=1,10
00140 INGR1=RANF(0)*10
00150 INGR2=RANF(0)*10
00160 INGR3=RANF(0)*10
00170 INGR4=RANF(0)*10
00180 INT1=INGR1*((-1)**INGR2)
00190 INT2=INGR3*((-1)**INGR4)
00200 IF(I.EQ.6)INT2=(-5)
00210 IF(I.EQ.9)INT2=(-3)
00220 K=INT1*INT2
00230 PRINT 130,INT1,INT2
00240 130 FORMAT (2X,I3,*  X (*,I3,* )*)
00250 READ,INPT
00260 IF(K.EQ.INPT)GOTO 190
00270 GO TO 200
00280  190 IRIGHT=IRIGHT+1
00290 200 CONTINUE
00300 I=10HCITCANDATA
00310 WRITE(6)I,IRIGHT
00320 ENDFILE6
00330 END
```

Appendix 10

TYPE THE FOLLOWING PRODUCTS%

8 X (-9)
8 X (6)

-9 X (-4)

-3 X (2)

1 X (7)

2 X (-5)

-2 X (9)

-4 X (3)

7 X (-3)

-3 X (-0)

Figure 7

Table 4 Raw Data & Corrected Scores for Criterion Test

Male, 12

Corrected Score W	Score X	Time Y	Pre-Score Z
9.0	9	35	62%
9.0	9	35	81.5%
9.0	9	45	57.5%
9.0	9	33	71.5%
9.0	9	33	81.5%

N = 5
$\bar{X}$ = 9.0
Corrected W = 9.0 Score
Predicted Score = 9.0

Male, 13 - 14

Corrected Score W	Score X	Time Y	Pre-Score Z
8.3	9	22	72.0%
9.7	10	33	72.0%
10.0	10	34	79.0%
9.0	9	24	86.5%
8.9	9	36	75.5%
8.9	10	33	74.0%
9.3	9	34	86.0%
8.1	8	36	80.0%
9.8	10	33	75.5%
8.8	9	34	75.0%
8.1	8	34	81.5%

N = 11
$\bar{X}$ = 9.0
Corrected W = 8.9 Score
Predicted Score = -.0348 X, -.0477 Z + 13.835

Female, 12

Corrected Score W	Score X	Time Y	Pre-Score Z
9.1	9	38	91.0%
8.6	9	33	88.5%
9.1	9	36	79.0%
9.2	9	35	71.0%
9.4	10	32	95.5%

N = 5
$\bar{X}$ = 9.2
Corrected W = 9.1 Score
Predicted Score = -.0994 Y + .0201 Z + 10.447

Female, 13 - 14

Corrected Score W	Score X	Time Y	Pre-Score Z
5.9	6	33	75.0%
8.9	9	38	66.0%
10.2	10	42	81.0%
9.0	9	38	71.5%
9.8	10	32	73.0%
7.2	7	36	89.0%
9.8	10	23	91.5%
8.8	9	38	69.5%

N = 8
$\bar{X}$ = 8.7
Corrected W = 8.7 Score
Predicted Score = -.0292 X -.0149 Z + 10.9236

N = 29
$\bar{X}$ = 8.9
Corrected W = 8.9
Mean Time = 34.0
Mean Pre-Score = 77.6
Predicted Score = -.0038 Y
-.02546 Z
+ 10.10379

Male, 12

Corrected Score W	Score X	Time Y	Pre-Score Z
9.2	9	34	62.0%
8.7	9	34	89.0%
9.2	10	23	73.5%
9.4	10	30	84.5%
9.7	10	34	86.0%

N = 5
$\bar{X}$ = 9.6
Corrected W = 9.4 Score
Predicted Score W = -.0739 Y + .0199 Z + 10.3199

Male, 13 - 14

Corrected Score W	Score X	Time Y	Pre-Score Z
9.8	10	42	94.5%
10.3	10	24	71.0%
9.9	10	33	67.0%
9.8	10	37	68.5%
9.9	10	34	76.0%
8.8	9	38	74.5%
8.2	8	27	80.0%
10.1	10	30	78.0%
8.9	9	33	66.0%

N = 10
$\bar{X}$ = 9.6
Corrected W = 9.5 Score
Predicted Score = .0361 Y -.0112 Z + 9.9191

Female, 12

Corrected Score W	Score X	Time Y	Pre-Score Z
10.2	10	36	94.0%
9.9	10	37	86.0%
10.0	10	30	61.5%
10.0	10	33	76.0%
10.6	10	30	86.0%
9.2	9	34	87.5%
10.0	9	27	91.0%

N = 7
$\bar{X}$ = 9.7
Corrected W = 10.0 Score
Predicted Score = .0896 Y -.0247 Z + 8.8244

Female 13 - 14

Corrected Score W	Score X	Time Y	Pre-Score Z
10.7	10	40	81.5%
9.4	9	38	84.5%
9.8	10	34	74.0%
9.4	8	42	34.5%
9.5	9	38	66.5%
8.6	8	40	97.0%
9.5	10	32	75.5%
10.3	10	38	88.5%

N = 7
$\bar{X}$ = 9.1
Corrected W = 9.6 Score
Predicted Score = -.1996 Y + .0084 Z + 14.6212

N = 29
$\bar{X}$ = 9.5
Corrected W = 9.6
Mean Time = 33.8
Mean Pre-Score = 77.7
Predicted Score = -.01365 Y
-.0203 Z
+ 11.2631

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