A BASIC MATHEMATICS DIAGNOSTIC INSTRUMENT

by

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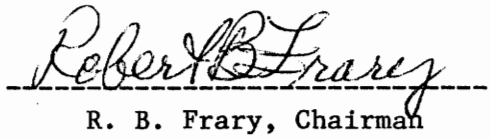

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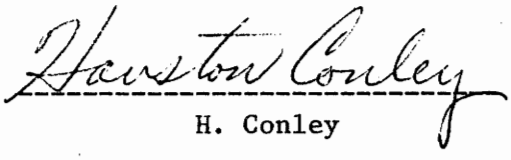

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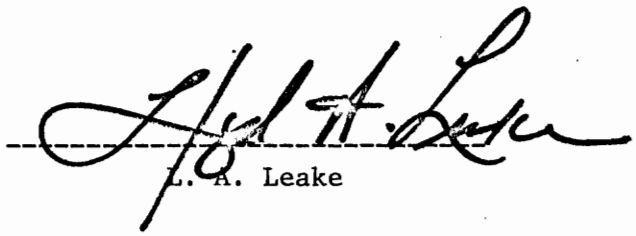

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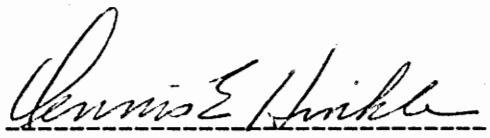

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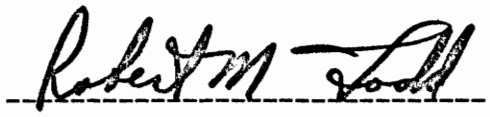

R. M. Todd

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Blacksburg, Virginia

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INTRODUCTION

At least ten percent of the students entering a community college each year are unable to meet the prerequisite requirements of their chosen curricula (Losak, 1973). Moore (1970) found that counselors usually use high school grades and standardized test scores to identify these students. The identified students were then placed by counselors into special classes designed to enable them to meet the necessary curricula requirements.

The instructors of these special classes seldom received sufficient data to accurately assess a student's abilities and aptitudes in a subject area. Often the information was a single test score. The information from standardized test scores, usually normative in nature, did not permit the interpretation of the student's strengths and weaknesses in any one skill area (Moore, 1970).

Stein (1972) found that a large portion of the entering community college population had a demonstrated lack of ability in mathematics, particularly arithmetic and beginning algebra. He recommended that diagnostic tests in mathematics be developed which would yield information about a student's previous content mastery, the student's propensity for errors, and the student's ability to apply content knowledge and computational skills in problem solving.

This study has focused upon the development of a test for community college students needing remediation in arithmetic and

beginning algebra. The test produced an assessment of a student's strengths along with his weaknesses in content and skill areas usually found in arithmetic and beginning algebra courses. Emphasis was placed on the use of test development techniques which enhance the reliability of the subtests of the instrument. Specifications for the test development were determined after considering the needs of the students as found in a review of the literature.

BACKGROUND OF THE PROBLEM

An awakened social conscience during the 1960's brought a national commitment to extending post-secondary educational opportunities to everyone. Many students who were previously unable to meet the entrance requirements of colleges and universities were admitted to community colleges. The community colleges were placed in the difficult position of attempting to meet the needs of academically underprepared students. In an effort to accommodate these underprepared students, community colleges initiated either special courses or special programs. Initially these courses were called "remedial". Since 1970 the less punative term "developmental" has been adopted (Lozak, 1973).

The instructional technique used in many developmental programs is to ascertain a student's level of performance in three basic skill areas: reading, communication skills, and mathematics. If the student has deficiencies in one or more of the basic skills, he is placed in a developmental course designed to eradicate weaknesses. The prescription of the course of study appropriate for each underprepared student is the responsibility of a developmental instructor, usually a subject

specialist. Consequently, the instructor is heavily dependent on accurate assessment of a student's previously learned skills and knowledge of content in a skill area.

CHARACTERISTICS OF ACADEMICALLY UNDERPREPARED STUDENTS

For this study the academically underprepared student is a student who does not meet the established criteria for entrance into a desired course or program offered by a community college (Losak, 1973). Other terms often used to label the academically underprepared student include: disadvantaged, deprived, remedial, developmental, marginal, and high risk. Academically underprepared was chosen because it is relatively free from etiological and pejorative connotations.

The descriptions of underprepared students are usually non-categorical and ill-defined (Losak, 1973). Losak, Jefferson and Sutton (1970) found four identifiable sub-groups of academically underprepared students:

1. Students with high levels of potential as assessed by individual tests of intelligence who have low records of achievement,

2. Students who have low records of achievement because of emotional problems,

3. Students with low achievement associated with minimal brain dysfunctioning, and

4. Students with low achievement associated with low intelligence.

No matter the sub-group in which an academically underprepared student belongs, Losak (1970) emphasized that the assumption cannot be made that

no previous learning has taken place. Losak recommended diagnostic assessment along with a student development program, including counseling, with referral to appropriate personnel in the field of learning disabilities.

With academically underprepared students perceptual styles are often inadequate or inappropriate to the demands of academic efficiency (Gordon and Wilkersen, 1966). In this same study, it was found that abilities of underprepared students tend to be better developed in physical rather than visual skills and in visual rather than aural skills. This fact makes the results of traditional forms of testing difficult to interpret and suggests that research should be done to develop more effective modes of assessing the abilities of underprepared students (Moore, 1970). Monroe (1970) found the profiles of underprepared students often showed language handicaps and incompetency in reading. Menne and Menne (1972) found that aural-visual presentations in redundant dual-channel modes benefit the poor reader. Scacht (1966) reported that inability to read and comprehend diagrams was a common source of errors made in problem solving, common fractions, and measurement. Also, failure to understand the decimal numeration system was found to be a common difficulty in the four operations with whole numbers, decimals, and fractions.

For clarity, the terminology "basic mathematics" has been used to refer to developmental courses in arithmetic and beginning algebra.

Roueche in a 1968 study of underprepared students in basic mathematics found the following characteristics:

1. A dislike for mathematics,
2. Lack of confidence in handling symbolism,
3. An approach to testing characterized by inability to organize information,
4. Emotional disturbances associated with awareness of personal inadequacy,
5. Lack of confidence in ability to communicate with mathematics instructors, and
6. A prevalent prediction of failure for self and peers in school situations.

Roberts (1968) found that there are at least four types of errors consistently made by underprepared students in basic mathematics. The error types were:

1. Wrong operation used,
2. Obvious computational error,
3. Defective algorithms used,
4. Random responses.

Roueche (1972) recommended that the design of diagnostic tests of basic mathematics students should allow for the differing perceptual styles of these students, should take into account the reading problems often prevalent, and should attempt to reduce the anxiety associated with the characteristics he found in 1968.

CURRENT PRACTICES

An entering academically underprepared student is usually admitted to the community college and placed in basic mathematics by counselors, not instructors (Moore, 1970).

Beal (1970) reported the reasons found for placement of a student into a basic mathematics course were to enable the student to continue into a regular mathematics course, to satisfy prerequisite requirements for some college course other than mathematics, to satisfy a high school or diploma requirement, or to satisfy a technical or vocational curriculum requirement.

Beal (1970) and Losak (1973) found that one or more of the following criteria are used to identify academically underprepared students: (Listing is from greatest to least frequency of use as reported by Beal.)

1. High school grade point average or previous grades in mathematics,
2. Standardized test scores,
3. Counselor or teacher recommendations,
4. Teacher constructed tests,
5. Self-referral.

It is not the purpose of this study to consider all the criteria used to identify academically underprepared students in basic mathematics. However, the use of standardized tests was investigated. In an effort to determine exactly what standardized tests were being used in community colleges with developmental programs, an

extensive review of literature was conducted. An ERIC search was made using the following descriptors: community/junior colleges-admissions criteria, testing, disadvantaged students, learning difficulties, learning experiences, mathematics, remedial programs/courses, and student characteristics; educational testing; adult education; multiple choice tests; criterion referenced tests/normed referenced tests; item analysis; test construction; error patterns; response styles; testing problems; test wiseness; student abilities; student placement; and testing programs.

The use of tests in basic mathematics programs was examined in the following journals: Two-Year Mathematics Journal, American Association of Community/Junior College Journal, Mathematical Association of America Monthly, and journals, pamphlets, books and manuscripts published by the National Council of Teachers of Mathematics. Tests available were reviewed in The Mental Measurements Yearbook series (Buros, 1953, 1959, 1965, 1972), Tests in Print (Buros, 1961), and Mathematics Tests Available in the United States (Braswell, 1972).

The most recent studies of developmental programs show that ninety-five percent of the community colleges use standardized test scores to identify and assign students to developmental programs (Moore, 1970). These standardized tests can either be described as college admissions/scholastic aptitude tests or as subject achievement tests (Losak, 1973).

College Admissions/Scholastic Aptitude Tests

College admissions tests are aptitude tests which are designed to provide an estimate of the students' potential for college work, independent of high school performance (Brown, 1971). Moore (1970) found that one-third of the community colleges used the School and College Ability Test (SCAT), twenty-one percent used the American Council on Education Test (ACE), and eighteen percent used the American College Test (ACT). Additionally, Beal (1970) found the Scholastic Aptitude Test (SAT), the Differential Aptitude Test (DAT), and the Educational Skills Test/College Edition were often used to identify academically underprepared students. In 1968, the College Entrance Examination Board published a community college placement instrument, Collegiate Guidance and Placement Test (CGP). Specific to mathematics, The ACT Mathematics Placement Examination and the CLEP General Examination in Mathematics are available; however, there is little evidence in the literature of their use in community colleges.

Mathematics Achievement Tests

A mathematics achievement test measures the extent to which a person has acquired mathematical content and has mastered certain skills, usually as a result of specific instruction (Brown, 1970). Usually the standardized mathematics achievement tests used in community colleges are survey tests; that is, they are designed to broadly sample knowledge and skills in mathematics (Stein, 1972).

Few community colleges have reported the use of standardized achievement tests in basic mathematics. The tests being used have usually been written for elementary and junior high school students (Braswell, 1972). Some of the tests available are as follows: California Arithmetic Tests; Iowa Test of Basic Skills - Test M; Tests of Adult Basic Education - Arithmetic Test (adapted from the California Arithmetic Test); Cooperative Mathematics Tests; California Achievement Tests, 1970 Edition - Mathematics; STEP Series II Mathematics Basic Concepts Test; Educational Skills Test/College Edition - Mathematics Test; and McGraw-Hill Basic Skills System - Mathematics Test (Braswell, 1972).

INADEQUACIES OF CURRENT PRACTICES

A different type of test is needed when working with students who have had difficulty in mastering a subject (Brown, 1971). A diagnostic test is a test used to locate specific areas of weakness or strength, and to determine the nature of weaknesses or deficiencies; it yields measures of the components or sub-parts of some larger body of information or skill (Brown, 1970). Since none of the standardized tests currently used in the community colleges are diagnostic in nature, they are not appropriate for the instructor to use to determine an individual course of remediation (Roueche, 1972). The normative information gleaned from standardized tests yields data which estimate the student's level of achievement. With academically underprepared students, the level of achievement is usually the fifteenth percentile

or below (Moore, 1970). This can be interpreted to mean that the student has a great degree of overall deficiency in mathematics. However, the student may have mastered some of the skills required in basic mathematics.

The dilemma for the developmental mathematics instructor is that the standardized tests are administered and interpreted by counselors and the tests are used only to identify basic mathematics students. The instructor meets his basic mathematics students the first day of classes and he is supposed to be able to discern at what level the student is performing at this time (Moore, 1970). Sheldon (1970) suggested that there needs to be additional testing, diagnostic in nature, for a period of time after the student enters basic mathematics. Sheldon recommended that the diagnosis of strengths and weaknesses must be based upon the curricular objectives of the underprepared student. Thus, it appears that if the instructor had a profile of a student's strengths and weaknesses in computational skills and in content knowledge of arithmetic and beginning algebra, a program of study could be devised for the individual student. The need for an appropriate diagnostic test taking into account the characteristics of the underprepared student in basic mathematics is apparent.

Diagnostic Tests Available in Basic Mathematics

All available basic mathematics diagnostic tests deal mainly with arithmetic skills. Descriptions of three diagnostic tests have been done as examples.

Diagnostic Tests and Self-Helps in Arithmetic (Brueckner, 1955) was designed for grades three through twelve. This instrument consists of twenty-three tests for screening basic facts, whole numbers, fractions, decimals, percents, and measurement. The student takes each of the pencil-and-paper tests in sequence and at the end of each test he is referred to specific self-helps which must be mastered before he can proceed to the next test (Buros, 1959). Since this instrument is rather inflexible in its organization, does not cover any of the topics found in beginning algebra, and has not been revised in twenty years its usefulness in basic mathematics is dubious.

The Prescriptive Mathematics Inventory, Level C, (Gessel, 1971) is a criterion referenced, multiple-choice format, test for grades seven through nine (Braswell, 1972). This test is a diagnostic instrument and covers all the skills and content usually found in a basic mathematics course except applications and problem solving. Great stress is placed upon the use of mathematical symbolism, set notation, and mathematical terminology which penalizes the students with reading problems.

The KeyMath Diagnostic Arithmetic Test (Connolly, Nachtman, and Prichett, 1971) is designed for pre-school through sixth grade and for older students with severe arithmetic deficiencies (Braswell, 1972). KeyMath is an individually administered, criterion referenced test which produces a profile of strengths and weaknesses for each student. Since each item of the KeyMath Diagnostic Arithmetic Test is read to the student, the reading problem is circumvented. Major

objections to this test are that it takes a long time to administer to each student and it covers only the arithmetic portion of the basic mathematics content.

Several of the standardized achievement tests previously cited and others of this type produce diagnostic reports on arithmetic skills. However, Junge (1972) found that not only was diagnostic testing needed, but that an item analysis of errors and the determination of the nature of these errors are crucial in the planning of appropriate learning experiences. Furthermore, Cross (1971, 1973) found that one of the major factors influencing the underachiever's development is the way the student perceives he is performing. The list of characteristics by Roueche (1968) echoes this finding. None of the diagnostic tests surveyed produced either a diagnosis of the types of errors consistently made by the students or information about the student's perception of his test performance.

PURPOSE OF THE STUDY

The purpose of this study was to develop a diagnostic test in basic mathematics appropriate for underprepared students. The objectives of the Basic Mathematics Diagnostic Instrument (BMDI) were designed to meet the needs of both basic mathematics instructors and the students who have been identified as needing remediation in basic mathematics. Although the students probably have been identified as having overall deficiencies, the BMDI needed to produce information which determined specific strengths and weaknesses of each individual in basic mathematics.

The objectives of the BMDI were as follows:

1. To identify strengths and weaknesses in the content areas of numeration: whole numbers, fractions, decimals, percents, integers, and rational numbers.

2. To identify computational skills and weaknesses in the four arithmetic operations over the content areas.

3. To ascertain the student's ability to apply his knowledge of content and arithmetic skills through problem solving.

4. To determine the types of errors consistently made by the student.

It was assumed that if the instructor had the information produced by the BMDI, he would place the underprepared student at an appropriate point in a course which would allow him to function successfully and still be challenged. Furthermore, an appropriate basic mathematics sequence would be designed for the student to remediate his weaknesses and would not require unnecessary repetition of content and skills already mastered.

Specifications for Test Development

In light of the characteristics of the underprepared student as cited in the review of the literature, the following specifications for the BMDI were made:

1. The terminology and symbolism of mathematics were held to a minimum. This did not mean that the content was avoided but rather was stated in such a manner that the student could respond without being penalized because of lack of vocabulary.

2. The BMDI was produced in redundant dual-channel (aural and visual) modes to reduce the reading problem.

3. The BMDI was made in multiple-choice format to give the student plausable alternative responses to encourage recall.

To aid the basic mathematics instructor in the administration and interpretation of the BMDI the following specifications were designated:

1. The BMDI was to be group administered; however, the data produced individual diagnostic information.

2. The BMDI was a slide-tape presentation administered by the instructor. The syncronized slide-tape presentation permitted standardization of the test in that all students had an equal opportunity to respond to all test items.

3. The multiple-choice format was used to enhance reliability, to make the test easier to score, and to make the error diagnosis easier.

4. The BMDI was to produce a profile permitting the immediate diagnosis of a student's strengths and weaknesses.

5. The BMDI needed to produce a profile of errors to indicate the student's propensity for specific types of errors.

6. An attitude survey was included at the end of each subtest to give an indication of the student's perception of his performance in a subtest area.

7. Individual profile charts were produced to allow quick recording of performance and to assist in data interpretation.

Chapter 2

TEST DEVELOPMENT METHODOLOGY

> The development of a diagnostic test starts with the identification of the component elements making up a skill; then groups of items (subtests) are developed to measure each component (Brown, 1971: 104).

The components of the BMDI were determined primarily by the topics suggested in the Remedial Mathematics Newsletter, Volume 2, 1975 (Curriculum Committee of the New York State Mathematics Association of Two Year Colleges, 1975). Secondarily, content was determined by reviewing arithmetic and algebra texts (mostly programmed) used in community colleges, by surveying course descriptions in community college catalogues, and by reading critiques of developmental mathematics texts found in the Two-Year College Mathematics Journal.

The content to be covered by the BMDI was determined to be:

Subtest I: Numeration

- A. Whole numbers
- B. Fractions
  - 1. Proper
  - 2. Improper
  - 3. Mixed
- C. Decimals
- D. Percents
- E. Integers
- F. Rational Numbers

Subtest II: Addition

A. Whole numbers

B. Fractions

C. Integers

D. Rational Numbers

Subtest III: Subtraction

Covers the same areas as Addition

Subtest IV: Multiplication

Covers the same areas as Addition

Subtest V: Division

Covers the same areas as Addition

Subtest VI: Problem Solving

Applications of skills covered in Subtests I - V.

Subtest VII: Elementary Algebra

A. Algebraic Expressions

1. Evaluation

2. Simplification

B. Equations in One Unknown

From the above content outline, the author developed 195 short-answer test items. The distribution of items according to the subtest area was:

Subtest	Number of Items
1. Numeration	66
2. Addition	22
3. Subtraction	16

Subtest	Number of Items
4. Multiplication	23
5. Division	26
6. Problem Solving	25
7. Elementary Algebra	17
	195 Total

The 195 items were grouped into six sets by taking every sixth item. These six sets became six tests which were administered to a selected population of high school students. The high school students were students taking General Mathematics 9, Introduction to Algebra (Grade 9), or Consumer Mathematics (Grades 11 or 12). This population was chosen because these students are typical of the students identified as needing basic mathematics in the community college. Permission was granted to administer the six tests in a Roanoke County, Virginia, high school. All the mathematics teachers in the high school volunteered to administer the tests with the understanding that no student would be compelled to take a test. A total of 225 students in ten classes took one of the six tests. The directions given were: "Show all necessary work on your test paper and omit any item with which you are unfamiliar." The minimum number of students taking any one of the tests was thirty-five and the maximum was forty-one. Data tabulated on each of the test items were percent getting item correct, percent getting item wrong, and percent omitting item.

Brown (1971) suggested that the most appropriate way to build a multiple-choice test was to extract the item distractors from the most frequent incorrect responses on a test first produced in short-answer format. For an item to be included in the BMDI data produced on each of the 195 items were screened according to the following criteria:

Criterion 1: At least fifteen percent of the students making a response must have made a correct response and at most eighty percent of the students responding got the item correct.

Criterion 2: A "consistent" error was defined to mean that at least ten percent of the students missing an item made the same incorrect response. At least three consistent error responses had to be observed for the item to be included in the BMDI.

Application of the two criteria produced either items with three consistent error distractors and a "none of these" distractor or four consistent error distractors. The selected items were then placed into multiple-choice format. In this form there were sixty-two potential test items. Each of the consistent error distractors was analyzed for type of error made by examining the student's solution. The types of errors were grouped into seven categories.

1. Wrong operation used

   This category implies that the student used an arithmetic operation other than the one symbolized or designated in the item.

Example:

Given: 6 x ____ = 1

Response: 6

Analysis: The student used the operation of division rather than multiplication.

2. Defective algorithm used

This category suggests that the student has used an incomplete or inaccurate solution process.

Example:

Given: Round 432.78 to the nearest ten.

Response: 440

Analysis: The student used the incorrect algorithm of rounding upward in the tens' position although the units' digit was less than five.

3. Lack of understanding of content

This category leads one to conclude that the student is either unaware of the solution process and/or does not understand some of the mathematical terminology used.

Example:

Given: Change 97% to a common fraction.

Response: 1/97

Analysis: Although the student is aware of the appearance of a common fraction, he does not know the meaning of the percent symbol as related to conversion to fractions.

4. Obvious computational error

This category indicates that the student understands both the content and the algorithm but has merely computed incorrectly.

Example:

Given: 1.10 - 1.01 = ?

Response: 1.09

Analysis: Clearly the student understands the subtraction process but carelessly placed a 1 in the units position.

5. Ignored necessary symbol, not operation

This category means that the student chose to disregard a mathematical symbol other than one which denoted an arithmetic operation. This category appears most often when working with integers or rational numbers.

Example:

Given: $(^{-}5) + 8 = ?$

Response: 13

Analysis: The student added but he ignored the minus sign in front of the first numeral.

6. Reading

Although this category could clearly be defined on a pencil-and-paper test, it can be interpreted in the BMDI to also denote failure to follow directions. In this category the student has not responded to all the

requirements of the problem although he appears to know the mathematical terminology.

Example:

Given: How many whole numbers are between 7 and 2?

Response: 3, 4, 5, and 6

Analysis: Clearly the student can solve the problem, he simply did not answer the question, "How many?".

7. Random response

This category describes responses which are impulsive responses or the student guessed.

Example:

Given: $(^{-}5) \times \_\_\_\_ = 5$

Response: 5

Analysis: The student impulsively chose one of the numerals indicated in the problem.

Response: 2

Analysis: The student has made no attempt to solve the problem but has merely guessed.

The sixty-two potential test items with error diagnoses were presented to a panel of experts for their consensus on the wording of the test items and the diagnosis of errors. The panel included:

Dr. Robert B. Frary, College of Education and Consultant in Measurement and Evaluation, Virginia Polytechnic Institute and State University.

Dr. Harold Schoen, Departments of Mathematics and Secondary Education, University of Iowa.

Dr. Robert M. Todd, Department of Mathematics and Division of Curriculum and Instruction, Virginia Polytechnic Institute and State University.

Unanimous agreement was reached on fifty-eight of the sixty-two test items.

The final distribution of test items over the subtest areas was:

Subtest	Number of items
1. Numeration	19
2. Addition	9
3. Subtraction	5
4. Multiplication	7
5. Division	7
6. Problem Solving	8
7. Elementary Algebra	3
	58 Total

The final distribution of error types within the distractors was as follows:

Error type	Number of distractors
1. Wrong operation used	17
2. Defective algorithm used	49
3. Lack of understanding of content	78
4. Obvious computational error	16
5. Ignored necessary symbol, not operation	10

Error type	Number of distractors
6. Reading	15
7. Random response	40
	225 Total

Of the 232 distractors seven were "none of these" responses which were not categorized. The distractors and the correct responses were listed on each item by randomly drawing the corresponding numbers from a container of marbles numbered one through five except for the "none of these" responses which were always placed in the fifth position.

A student perception of performance survey was developed in a four choice multiple-choice format to be presented to the student after each of the seven subtests (See Appendix A). Including title, subtitle, and directions frames, a total of seventy-five 2" x 2" photographic slides were made from printed posters.

To determine the amount of time necessary for solving the test items and for completing the identification portion of the student answer sheet, the slides were shown to two secondary students who had a record of need for remediation in arithmetic and beginning algebra. The students viewed each slide while the item was simultaneously read to them. The session was recorded on a cassette tape. From the tape it was evident that different test items required different amounts of time. The total testing time was approximately forty-two minutes. The tape for the BMDI was made using the necessary times for item responses as established in the session described above. Out of concern for the

standardization of test administration while field testing, a syncronizer was used in the final taping which permitted the slides to change automatically via an electronic impulse recorded on the right channel of a stereo cassette tape.

The final step in the production of the BMDI was the preparation of profile sheets. These profile sheets are primarily graphical representations of the student's responses on the test (See Appendix B). Four profile sheets were produced per student. The purpose of each of the profiles was as follows:

1. Subtest profile

   Purpose: To present the strengths and weaknesses of the student in each of the seven subtest areas.

2. Supplementary subtest profile

   Purpose: To produce strengths and weaknesses of the student in five categories: whole numbers, fractions, decimals, percents, and integers across operations. This profile was simply a repartition of the BMDI done in an attempt to make test results more closely parellel content sequencing of a greater number of basic mathematics texts.

3. Error type profile

   Purpose: To give an indication of the student's propensity for specific types of errors.

4. Perception of performance survey

   Purpose: To record the student's responses to how he perceived he had performed on each of the seven subtests of the BMDI.

The methodology assumed in establishing the areas of strength and weaknesses was as follows:

1. If the student responded correctly on more than two-thirds of the test items in a given category then he showed strength.

2. If the student got between one-third and two-thirds of the items correct within a category, then there is indication of some weakness.

3. If the student made less than one-third correct responses, then he showed definite weakness.

Similarly the propensity for errors was interpreted. If the student made less than one-third of the possible number of errors within an error category, his propensity was low for that type of error. If he made between one-third and two-thirds of the possible number of errors, then he showed propensity for a given error type. If he made errors in excess of two-thirds of the possible number of errors within a category, then he had definite propensity.

SUMMARY

The test development methodology used in the BMDI was comprized of eight stages.

1. Identification of subtest areas and composition of test items in pencil-and-paper format.

2. Administration of the pencil-and paper test items to a selected population of students to obtain decoy responses.

3. Analysis and categorization of student errors.

4. Selection of criteria for item retention and screening of the items.

5. Production of items in multiple-choice format.

6. Presentation of items with error diagnosis to a panel of experts.

7. Technical production of the BMDI as a slide-tape presentation.

8. Development of profile sheets for teacher use.

A complete duplication of the script, slides, and error diagnosis appears in Appendix C.

Chapter 3

FIELD TESTING OF THE BASIC MATHEMATICS DIAGNOSTIC INSTRUMENT

In the development of a test it is necessary that the field testing be done on a sufficiently large and representative sample of the population for which the test is designed. The field study will then enable the test-maker to make further judgements about the items of the test, to estimate the test-retest reliability, and to repair any faults in test design (Brown, 1971).

THE SAMPLE

The BMDI was administered to entering community college students who had no previous experience in basic mathematics at the post-secondary level. All 435 students who participated in the field study had been placed into either an arithmetic course or a beginning algebra course. The BMDI was administered no later than the third class meeting.

The field study was conducted at four community colleges in Virginia. Each of the four colleges were selected to participate in the study on the basis of the diversity of curricular offerings in degree, certificate, and diploma programs and because of the contribution made in gaining representation of all types of students in terms of age, sex, race, geographic locale, and ethnic origin.

Central Virginia Community College, Lynchburg, Virginia, represented an urban/sburban student population. The age range of the

students was from eighteen to around fifty. The student ratios in terms of sex and race appeared about one to one. One hundred students from Central Virginia Community College participated in the field test.

The Downtown Campus of J. Sargeant Reynolds Community College is located in the center of Richmond, Virginia. This school represented an inner-city population. The one hundred, forty-six students who were tested were primarily blacks and low-income whites ranging in age from 18 to 40. Females were a majority in several classes.

New River Community College represented the rural, Appalachian population. The students were predominantly male, eighteen to twenty-five years of age representing lower to middle class socioeconomic levels. Eighty-seven students participated from New River Community College.

The Virginia Beach Campus of Tidewater Community College located in Virginia Beach, Virginia near several large military bases represented a very diverse population in terms of ethnic origin, race, and socioeconomic levels. The classes were equal in male-female representation and most students were over thirty years of age.

TEST ADMINISTRATION AND SCORING

Since the BMDI was a slide-tape presentation the following audio-visual devices were needed: a Kodak Carrousel slide projector, a projection screen, a stereophonic cassette tape player, and a slide syncronizer. The test was administered in regular classroom settings with the lighting dimmed sufficiently for the students to see the

projection screen yet sufficient light was available for them to see the answer sheet and to do scratch work. In each of the twenty-six presentations the students were furnished answer sheets, Number 2 pencils, and scratch paper.

All scoring of the students' tests was done using an optical scanner and a computer. The answer sheets were read by the optical scanner and the data were transferred to punched cards. A program was written to output subtest total scores, error-type total scores, and the perception-of-performance responses on each individual. These output data were transferred onto individual profile sheets and the profiles were drawn by hand. Although scoring mats could have been produced for instructor scoring, the need for fast return of the diagnostic data to the instructors made computer scoring more feasible. All student profiles were available for the instructor's use within one week of testing.

ITEM-SUBTEST TOTAL SCORE ANALYSIS

The BMDI contained fifty-eight test items and seven perception-of-performance surveys. The fifty-eight test items were initially grouped into seven subtests. The seven original subtests partitioned the items according to knowledge of numerals, knowledge of arithmetic operations, and ability to solve written problems. In response to teacher requests for more conformity to the texts used in basic mathematics, a second partition of the BMDI was done to group items according to five numerical categories, whole numbers, fractions,

decimals, percents, and integers. This second partition was called the "supplementary" subtests. All item analyses were done using the VPI & SU Test Scoring and Analysis System (Frary, 1974).

The item analysis of the BMDI was done on each item relative to its membership in a subtest. Thus, all item-total correlations were with respect to subtest scores and were point-biserial correlations. Guilford (1956) suggested that item-total correlations within the range of .30 to .80 were acceptable with large sample populations.

One of the item selection criteria used in the preliminary development of the BMDI was at least fifteen percent of the students responding to an item had a correct response. This criterion was re-applied to the item-initial subtest and the item-supplementary subtest analyses shown in Tables 1 and 2, respectively. Only two items fulfilled neither Guilford's correlation criterion nor the response criterion. Two additional items did not meet the correlation criterion alone. Table 1 shows three items, all within the numeration subtest, which did not meet the established criteria with respect to the initial subtests. Table 2 shows three items, one each in the whole numbers subtest, the fractions subtest, and the decimals subtest, which did not meet the criteria with respect to the supplemental subtests. Two of the items were common to both the initial and the supplementary subtest analyses. This yielded a total of four items which do not meet either the correlation or response criteria. The item numbers are 6, 9, 10 and 37.

Table 1

Summary of Item-Initial Subtest Analysis

N = 435 Subtest	% of sample getting item right	Item-subtest correlation	% omitting	% of students responding getting item right
I. Numeration				
Item 1	33	.43	2	34
2	54	.46	6	57
3	47	.40	3	48
4	47	.50	8	51
5	44	.50	14	51
6	14	.27[2]	3	14[1]
7	46	.48	11	52
8	33	.54	10	37
9	8	.11[2]	16	9[1]
10	42	.26[2]	5	44
11	59	.40	5	62
12	48	.34	5	51
13	43	.38	12	49
14	46	.57	10	51
15	23	.38	20	29

Table 1 (continued)

N = 435 Subtest	% of sample getting item right	Item-subtest correlation	% omitting	% of students responding getting item right
16	31	.42	3	32
17	77	.45	5	81
18	61	.51	14	71
19	57	.57	3	59
II. Addition				
Item 21	34	.59	10	38
22	46	.54	7	49
23	38	.60	22	49
24	45	.59	5	47
25	46	.61	16	55
26	65	.41	4	68
27	62	.58	7	67
28	42	.66	25	56
29	47	.65	11	53
III. Subtraction				
Item 31	54	.56	5	57
32	36	.41	3	37

Table 1 (continued)

N = 435 Subtest	% of sample getting item right	Item-subtest correlation	% omitting	% of students responding getting item right
33	34	.57	5	36
34	24	.60	27	33
35	20	.54	24	26
IV. Multiplication				
Item 37	40	.47	27	55
38	33	.59	16	39
39	25	.61	23	32
40	46	.50	6	49
41	46	.46	6	49
42	37	.52	9	41
43	23	.46	25	31
V. Division				
Item 45	32	.57	13	37
46	31	.52	28	43
47	31	.60	5	33
48	57	.48	11	64
49	45	.50	13	52

Table 1 (continued)

N = 435 Subtest	% of sample getting item right	Item-subtest correlation	% omitting	% of students responding getting item right
50	43	.52	16	51
51	43	.59	6	46
VI. Problem Solving				
Item 53	61	.64	16	73
54	76	.39	4	81
55	29	.59	12	33
56	36	.55	9	40
57	33	.57	14	39
58	31	.49	17	37
59	50	.59	7	54
60	45	.52	14	52
VII. Elem. Algebra				
Item 62	17	.73	42	29
63	28	.68	20	35
64	36	.80	27	49

[1]Does not meet the response criterion.

[2]Does not meet the correlation criterion.

Table 2

Summary of Item-Subtest Supplementary Analysis

N = 435 Subtest	% of sample getting item right	Item-subtest correlation	% omitting	% of students responding getting item right
I. Whole Numbers				
Item 1	33	.50	2	34
2	54	.50	6	57
6	14	.37	3	14
9	8	.16[2]	16	9[1]
11	59	.45	5	62
15	23	.50	20	29
33	34	.49	5	36
45	32	.50	13	37
57	33	.56	14	38
58	31	.52	17	37
II. Fractions				
Item 4	47	.47	8	51
11	59	.41	5	62
12	48	.31	5	51
13	43	.38	12	49
14	46	.56	10	51

Table 2 (continued)

N = 435 Subtest	% of sample getting item right	Item-subtest correlation	% omitting	% of students responding getting item right
17	77	.46	5	81
18	61	.48	14	71
19	57	.57	3	59
21	34	.45	10	38
22	46	.54	7	49
23	38	.59	22	49
29	47	.52	11	53
34	24	.51	27	33
35	20	.48	24	26
37	40	.19[2]	27	55
38	33	.48	16	39
39	25	.44	23	32
43	23	.27	25	31
46	31	.45	28	43
51	43	.57	6	46
55	29	.45	12	33

Table 2 (continued)

N = 435 Subtest	% of sample getting item right	Item-subtest correlation	% omitting	% of students responding getting item right
III. Decimals				
Item 3	47	.42	3	48
5	44	.48	14	51
6	14[1]	.28[2]	3	14
7	46	.48	11	52
8	33	.51	10	37
15	23	.35	20	29
16	31	.42	3	32
19	57	.60	3	59
24	45	.53	5	47
31	54	.31	5	57
40	46	.44	6	49
41	46	.32	6	49
47	31	.54	5	33
48	57	.34	11	64
49	45	.39	13	52
50	43	.45	16	51
53	61	.59	16	73

Table 2 (continued)

N = 435 Subtest	% of sample getting item right	Item-subtest correlation	% omitting	% of students responding getting item right
54	76	.32	4	81
56	36	.48	9	40
60	45	.38	14	52
IV. Percents				
Item 10	42	.42	5	44
16	31	.49	3	32
17	77	.58	5	81
18	61	.58	14	71
59	50	.55	7	54
60	45	.52	14	52
V. Integers				
Item 25	46	.62	16	55
26	65	.50	4	68
27	62	.57	7	67
28	42	.66	25	56

Table 2 (continued)

N = 435 Subtest	% of sample getting item right	Item-subtest correlation	% omitting	% of students responding getting item right
32	36	.27	3	37
33	34	.58	5	36
42	37	.47	9	41

[1]Does not meet the response criterion.

[2]Does not meet the correlation criterion.

RELIABILITY OF SUBTEST SCORES

The reliability coefficient is a simple proportion which measures the extent to which the test scores are free of chance error. In test development the Kruder-Richardson Formula 20 (KR-20) has been most often applied to obtain the estimated internal consistency of the test material (Ferguson, 1971).

The subtest reliability estimates (KR-20's) are shown in Table 3. The range of the reliability estimates was .37 to .76 with only one subtest, subtraction, falling below .45. Since KR-20 is a conservative estimate based on test homogeneity, the reliability estimates for the BMDI subtests were within the range usually encountered for short subtests on instruments in the diagnostic category. For an example of interpretation of estimated test reliability coefficients on a standardized instrument, see Diagnostic Reading Scales (Examiner's Manual) by Spache (1971).

The standard error of measurement (SEM) provides an estimate of the degree to which each test score may be in error, and is thus useful for interpretation of individual scores. The chances are about two to one that the students' scores will differ from the true scores by no more than the standard error of measurement (Ferguson, 1971). The SEM's for the BMDI subtest appear in Table 3. The SEM's range from .63 on a three item subtest to 1.98 on a twenty item subtest.

Table 3

Subtest Raw Score Reliability Data

N = 435			Raw Score		
Subtest	No. of items	KR-20	Mean	Standard Deviation	Standard Error of Measurement
Numeration	19	.750	8.13	3.79	1.90
Addition	9	.755	4.25	2.57	1.27
Subtraction	5	.370	1.68	1.22	.97
Multiplication	7	.535	2.51	1.70	1.16
Division	7	.594	2.82	1.82	1.16
Problem Solving	8	.660	3.61	2.06	1.20
Elem. Algebra	3	.579	.81	.97	.63
Whole Numbers	10	.598	3.23	2.07	1.31
Fractions	21	.814	8.71	4.57	1.97
Decimals	20	.770	8.79	4.13	1.98
Percents	6	.467	3.05	1.50	1.10
Integers	7	.561	3.22	1.78	1.18

SUBTEST INTERCORRELATIONS

Since the BMDI was composed of subtests, the interrelationships of the subtests were ascertained using Pearson product-moment correlation coefficients. Although the BMDI was designed to test over the content area of basic mathematics, the subtests attempted to measure unique components of basic mathematics. The subtests should not be too highly correlated to justify the partitioning of the test. All subtest intercorrelations are shown in Table 4. The range of subtest intercorrelations was from .25 to .78. Since none of the correlations was greater than .80, the subtests appear not to be too highly correlated.

RELIABILITY OF ERROR-TYPE SCORES

Reliability estimates for the seven error-type scores are shown in Table 5. The relatively high KR-20's for two of the error types, defective algorithm used and lack of knowledge of content, indicated that when students in this sample were either unfamiliar with the mathematical concepts or did not know the correct solution process, then they consistently chose responses in these two categories. The low KR-20's established on three error-types indicate that the students' profile points representing these categories are of dubious value in error diagnoses. The low score means on each of these three error-types; wrong operation used, obvious computational error, and ignored necessary symbol--not operation, indicate that the students did not often select error responses of these types.

Table 4

Intercorrelations of Subtests

N = 435	Initial Subtests Intercorrelations						
Initial Subtests	I	II	III	IV	V	VI	VII
I. Numeration	1.00	.64	.49	.41	.64	.64	.43
II. Addition		1.00	.52	.36	.56	.60	.51
III. Subtraction			1.00	.30	.42	.47	.39
IV. Multiplication				1.00	.39	.25	.39
V. Division					1.00	.54	.40
VI. Problem Solving						1.00	.33
VII. Elem. Algebra							1.00

	Supplementary Subtests Intercorrelations				
Supplementary Subtests	I'	II'	III'	IV'	V'
I'. Whole Numbers	1.00	.67	.68	.45	.53
II'. Fractions		1.00	.78	.66	.55
III'. Decimals			1.00	.65	.49
IV'. Percents				1.00	.33
V'. Integers					1.00

Table 5

Error-Type Raw Score Reliability Data

N = 435 Error Type	No. of Items	KR-20	Raw Score Mean	Raw Score Standard Deviation	Raw Score Standard Error of Measurement
I. Wrong Operation Used	14	.184	1.68	1.31	1.18
II. Defective Algorithy Used	24	.678	5.98	3.37	1.91
III. Lack of Knowledge of Content	36	.637	10.77	4.16	2.51
IV. Obvious Computational Error	13	.227	2.01	1.40	1.23
V. Ignored Necessary Symbol, Not Operation	9	.125	.97	.96	.89
VI. Reading Error	11	.308	1.48	1.25	1.04
VII. Random Error	32	.329	3.35	2.03	1.66

If the same assumptions hold about KR-20's and SEM's that were made concerning the content subtest data, then four of the error-types appear to provide useful diagnostic information for the basic mathematics teacher.

ITEM-ERROR TYPES ANALYSIS

Each student received seven error-type scores which were produced by totaling the number of error responses the student chose within each error-type. Since each of the fifty-eight test questions had four error responses and since these responses were selected from the most frequent errors made on the pencil-and-paper form of the BMDI, frequently more than one of the responses within an item was designated to be the same type of error. (For examples, see Appendix C.) However, since a student could make only one response per item, the error analysis was done just as the subtest analysis was done. The item-error type analysis is shown in Table 6. The criterion, established in the preliminary development of the test, on error responses was that at least ten percent of the students making an error had to make the same error for the error to become an item error response. There were thirteen error responses in the field study of the BMDI which did not meet this criterion. If .20 is assumed to be the lowest acceptable correlation between error responses and error-type total scores, then there were a total of 28 error responses in the BMDI not meeting this minimum requirement. The totality of error responses not meeting both criteria was ten; the totality of error responses not

Table 6

Summary of Item-Error Type Analysis

N = 435 Error Type	% of sample making error	Item-Error type correlation	% omitting	Percent of students choosing incorrect response on item making error of this error-type	Number of responses of designated error-type within item
I. Wrong Operation Used					
Item 1	16	.29	2	25	1
11	20	.40	5	56	2
24	3	.18[2]	5	6[1]	1
25	18	.41	16	47	1
26	15	.30	4	15	2
33	3	.15[2]	5	5[1]	1
35	8	.14[2]	24	15	1
42	16	.31	9	30	1
48	10	.31	11	31	1
49	7	.24	13	17	1
54	9	.17[2]	4	45	1
57	12	.36	14	23	1
59	7	.26	7	16	1
60	29	.43	14	71	2

Table 6 (continued)

N = 435 Error Type	% of sample making error	Item-Error type correlation	% omitting	Percent of students choosing incorrect response on item making error of this error-type	Number or responses of designated error-type within item
II. Defective Algorithm Used					
Item 6	19	.36	3	22	2
7	26	.38	11	58	2
13	8	.23	12	18	2
16	32	.43	3	48	2
19	36	.55	3	90	3
21	52	.52	10	93	3
22	25	.45	7	53	2
23	34	.54	22	85	3
29	7	.21	11	17	1
34	21	.31	27	43	2
35	43	.42	24	77	2
37	34	.31	27	100	4
38	21	.34	16	41	2
39	48	.47	23	92	3
40	14	.21	6	29	1

Table 6 (continued)

N = 435 Error Type	% of sample making error	Item-Error-type correlation	% omitting	Percent of students choosing incorrect response on item making error of this error-type	Number of responses of designated error-type within item
43	11	.23	25	21	1
46	25	.33	28	61	3
47	57	.46	5	89	3
48	8	.12[2]	11	25	1
49	21	.18[2]	13	50	1
50	31	.28	16	76	2
57	21	.25	14	45	2
59	9	.25	7	21	1
60	5	.12[2]	14	12	1
III. Lack of Knowledge of Content					
Item 1	16	.25	2	25	1
2	34	.35	6	85	3
3	31	.34	3	62	3
4	29	.34	8	64	2
5	20	.23	14	48	1
6	65	.06[2]	3	78	2

Table 6 (continued)

N = 435 Error Type	% of sample making error	Item-Error-type correlation	% omitting	Percent of students choosing incorrect response on item making error of this error-type	Number of responses of designated error-type within item
7	17	.18[2]	11	40	2
8	48	.42	10	84	3
9	76	.25	16	100	4
10	21	.20	5	40	2
11	17	.20	5	47	2
12	10	.22	5	21	2
14	31	.41	10	70	3
15	53	.26	20	93	3
17	5	.17[2]	5	18	1
18	11	.26	14	44	1
24	43	.40	5	86	2
25	12	.27	16	25	1
28	16	.37	25	48	2
29	35	.38	11	83	3
31	18	.26	5	44	3
32	52	.13[2]	3	85	2
33	45	.36	5	74	2

Table 6 (continued)

N = 435 Error Type	% of sample making error	Item-Error-type correlation	% omitting	Percent of students choosing incorrect response on item making error of this error-type	Number of responses of designated error-type within item
40	31	.30	6	65	2
41	48	.27	6	100	3
42	19	.27	9	35	1
43	22	.17[2]	25	42	2
45	36	.28	13	65	2
48	14	.20	11	44	2
49	21	.18[2]	13	50	1
51	51	.49	6	100	4
58	14	.17[2]	17	27	1
59	16	.17[2]	7	37	1
62	42	.30	42	100	4
63	32	.23	20	62	2
64	29	.30	27	73	3

Table 6 (continued)

N = 435 Error Type	% of sample making error	Item-Error-type correlation	% omitting	Percent of students choosing incorrect response on item making error of this error-type	Number of responses of designated error-type within item
IV. Obvious Computational Error					
Item 12	22	.34	5	47	1
13	29	.39	12	83	1
22	7	.28	7	15	1
31	23	.34	5	56	1
34	9	.31	27	18	1
38	9	.23	16	18	1
45	19	.39	13	35	2
46	15	.36	28	37	1
50	6	.21	16	15	1
53	8	.30	16	35	1
54	3	.18[2]	4	15	1
55	41	.42	12	69	3
59	11	.28	7	26	1

Table 6 (continued)

N = 435 Error Type	% of sample making error	Item-Error-type correlation	% omitting	Percent of students choosing incorrect response on item making error of this error-type	Number of responses of designated error-type within item
V. Ignored Necessary Symbol, Not Operation					
Item 16	19	.38	3	29	1
17	9	.37	5	50	1
18	6	.43	14	24	1
19	4	.28	3	10	1
24	4	.22	5	8[1]	1
26	12	.37	4	39	1
27	25	.47	7	81	2
28	10	.38	25	30	1
64	7	.26	27	19	1
VI. Reading					
Item 1	31	.48	2	48	1
2	6	.28	6	15	1
4	7	.18[2]	8	16	1
5	16	.43	14	38	2

Table 6 (continued)

N = 435 Error Type	% of sample making error	Item-Error-type correlation	% omitting	Percent of students choosing incorrect response on item making error of this error-type	Number of responses of designated error-type within item
10	12	.38	5	23	1
13	9	.34	12	20	1
15	3	.23	20	5[1]	1
17	4	.21	5	94	1
18	8	.28	14	32	2
53	10	.39	16	43	2
56	43	.54	9	78	2
VII. Random					
Item 1	3	.17[2]	2	4[1]	1
3	20	.14[2]	3	40	1
4	9	.20	8	20	1
5	6	.19[2]	14	14	1
8	9	.15[2]	10	16	1
10	20	.23	5	38	1
12	15	.27	5	32	1
14	13	.23	10	30	1
16	14	.20	3	25	1

Table 6 (continued)

N = 435 Error Type	% of sample making error	Item-Error-type correlation	% omitting	Percent of students choosing incorrect response on item making error of this error-type	Number of responses of designated error-type within item
17	1	.08[2]	5	5[1]	1
21	4	.15[2]	10	7[1]	1
23	6	.23	22	15	1
25	11	.25	16	29	2
26	3	.23	4	10	1
27	6	.30	7	19	2
28	7	.22	25	21	1
32	10	.16[2]	3	16	2
33	13	.19[2]	5	21	1
35	5	.19[2]	24	9[1]	1
39	4	.22	23	8[1]	1
40	3	.17[2]	6	6[1]	1
41	1	.01[2]	6	2[1]	1
42	20	.30	9	37	2
47	8	.23	5	13	1
49	3	.07[2]	13	7[1]	1
50	5	.23	16	12	1

Table 6 (continued)

N = 435 Error Type	% of sample making error	Item-Error-type correlation	% omitting	Percent of students choosing incorrect response on item making error of this error-type	Number of responses error-type error-type within item
51	21	.24	6	41	1
53	5	.25	16	22	1
56	11	.27	9	20	2
57	21	.28	14	40	1
58	38	.34	17	73	3
63	19	.35	20	37	2

[1]Does not meet error response criterion.

[2]Does not meet correlation criterion.

meeting at least one criterion was 37. However, neither a survey of diagnostic test manuals nor a perusal of Standards for Educational and Psychological Tests and Manuals (French and Michael, 1966) permitted the establishment of any minimum criteria for error responses. Furthermore, two of the 37 questionable error responses were from the four items previously rejected, and most of those remaining were either marginal with respect to the criteria or were in the three scales with doubtful reliability estimates.

INTERCORRELATIONS OF ERROR-TYPES

The intercorrelations of the error-types are shown in Table 7. The greatest Pearson product-moment correlation, .58, was between lack of knowledge of content and defective algorithm used. Although there were greater opportunities within the error responses for the students to make these types of errors, the profiles often showed that students weak in knowledge of mathematical content were likewise weak in knowledge of the correct solution process. Any correlations between the three error-types with low reliability estimates and other error-types do not permit conclusions about these relationships.

PERCEPTION OF PERFORMANCE SURVEY

At the end of each of the BMDI initial subtests, the student was requested to indicate his perception of his performance on the subtest completed. The responses were scaled from 1, meaning performed well, to 4, meaning performed poorly. The correlations between actual

Table 7

Intercorrelations of Error-Types

Type of Error	1	2	3	4	5	6	7
1. Wrong Operation Used	1.00	.36	.29	.18	.19	.19	.25
2. Defective Algorithm Used		1.00	.58	.35	.27	.39	.39
3. Lack of Knowledge of Content			1.00	.35	.24	.36	.34
4. Obvious Computational Error				1.00	.16	.28	.22
5. Ignored Necessary Symbol, Not Operation					1.00	.11	.21
6. Reading Error						1.00	.22
7. Random Error							1.00

N = 435

subtest score and perceived subtest performance is shown in Table 8. The negative correlations were the result of the reversed direction of the scores and the perception scale. Contrary to the characteristic of unrealistic estimation of ability found by Roueche (1968), these students appeared on the average to make realistic appraisals of their performance on the BMDI. However, there is evidence that some students did not accurately perceive their performances since the correlations ranged from -.60 to -.40. All the correlations in Table 8 were significant at .001 level of significance using a one-tail test.

VALIDITY

The BMDI was a diagnostic instrument of content mastery; hence, its validity would be primarily concerned with the relevance of the items to the requirements in basic mathematics courses. The test items were constructed using relevant curriculum materials and represented basic objectives of arithmetic and beginning algebra courses in community colleges.

In an effort to ascertain the value of the BMDI student profiles to basic mathematics teachers, each instructor who participated in the field study was requested to evaluate the BMDI after he had had an opportunity to study the student profiles. A total of thirteen instructors participated in the field study. Table 9 shows the tabulated results of the teacher questionnaires. (See Appendix D for the questionnaire.)

Table 8

Correlations Between Initial Subtest Performance and Perceived Performance

N = 435 Subtest	Pearson product-moment correlation
Numeration	-.52
Addition	-.56
Subtraction	-.45
Multiplication	-.41
Division	-.47
Problem Solving	-.48
Elementary Algebra	-.45

(All significant at .001 level, one-tail test)

Table 9

Tabulation of Teacher Ratings of BMDI

	Evaluation						
	Poor			Excellent			
Question	1	2	3	4	Omitted	Mean	Topic
A	1	10	2	0	0	2.08	Subtest Profiles
B	0	10	1	2	0	2.38	Slide Tape Presentation
C	5	6	2	0	0	1.77	Error Profile
D	4	7	1	1	0	1.92	Student Perceptions of Performance Profile
E	1	6	4	0	2	2.27	Overall

N = 13

Apparently, the instructors found the initial subtests/ supplementary subtests profile sheets informative to some degree. The error-type profiles and the perception of performance surveys were not deemed very helpful in aiding instruction. All viewed the dual-mode, slide-tape presentation of assistance to the basic mathematics students. The diagnostic data of the BMDI when compared to other available information concerning basic mathematics students was assessed to be equal or better for determining student abilities and for counseling students in basic mathematics.

Chapter 4

CONCLUSIONS, DISCUSSION AND RECOMMENDATIONS

CONCLUSIONS

The purpose of this study was to develop a diagnostic test appropriate for underprepared students in basic mathematics. The test was designed to aid basic mathematics teachers by identifying specific strengths and weaknesses of students previously identified as needing remediation in basic mathematical concepts and skills. Any conclusions concerning the efficacy of the BMDI were determined from how well the test results met the stated objectives of the test. Since teacher opinion of how well the BMDI goals were met differed from statistical evidence in some instances, the statistical inferences will first be made and then the teacher inferences will be discussed.

Statistical Results

The first three of the objectives of the BMDI were as follows:

1. To identify student strengths and weaknesses in knowledge of different kinds of numbers.

2. To determine levels of skill in arithmetic operations.

3. To determine the ability of the student to apply content knowledge and operational skills in problem solving.

The reliability estimates, derived from the sample (N = 435), on sub-tests measuring these three objectives were deemed within the range usually encountered on diagnostic tests. This outcome meant that

student scores were considered sufficiently reliable for the prescription of individual programs of remediation for each underprepared student. The standard errors of measurement of the subtests of the BMDI further reinforced this conclusion.

The determination of the propensity of a student to make specific types of errors was a fourth objective of the BMDI. This objective may not have been met in its entirety. Of the seven error-types categorized from student responses on a pencil-and-paper form of the BMDI, only four of the error-types, defective algorithm used, lack of knowledge of content, reading errors, and random errors, yielded reliability estimates sufficiently high to justify production of error scores. The three remaining error-types, wrong operation used, obvious computational error, and ignored necessary symbol--not operation, produced low reliability estimates. These low estimates in part reflected very low percentages of the students in the sample choosing responses keyed to these three error-types. Thus, identification of error propensity in these three error-types was doubtful; however, these areas may not be of critical concern for the population of interest.

The item-subtest analyses indicated that four items of the BMDI should be deleted because they were either too difficult of because they did not meet the correlation criterion of at least .30 with the content subtests of which they were members.

Statistically the BMDI appeared to produce information of sufficient reliability for the instructor to place a student in an

appropriate area of a basic mathematics course on a level at which he could function successfully and still be challenged. Furthermore, the diagnostic profiles of the student would permit the instructor to design an individual sequence of remediation in basic mathematics without requiring the student to cover mathematical content previously mastered.

Evaluation by Teachers

Although the statistical analyses confirmed that the BMDI could be used in determination of an individual course of remediation for each student, the instructional modes and content designs of the basic mathematics courses of the four community colleges participating in the field study tended not to support individualization. Furthermore, the subtest structure of the BMDI even with the two partitions of the test did not precisely parallel the sequencing of course content in the various classes. Further partitioning of the BMDI was not considered practical since the two partitions made were based on the two most prevalent approaches to sequencing of basic mathematics content, namely arithmetic operations across number systems versus number systems across arithmetic operations. One factor influencing the lack of flexibility of the courses were that the courses were built around adopted texts, either programmed or traditional. Although programmed texts permitted self-pacing of instruction, the content sequencing tended to prevent the skipping of units after an area of weakness within a unit had been detected.

The teachers tended to agree that the first three objectives were met in that they believed the content subtest profiles were of some use. For the most part, these profiles were viewed as helpful whenever a student showed strength on all subtests. Whenever the student showed overall strength he was usually changed from a developmental arithmetic course into a developmental beginning algebra course. In classes where programmed texts were used, the profiles permitted the instructor to identify the appropriate starting point in the text for the student. (These conclusions are based in part on written and oral comments of the teachers in addition to questionnaire responses.)

The BMDI was a slide-tape presentation in two redundant modes. This medium appeared to aid the students in focusing on one problem at a time and to reduce some of the reading problems of the underprepared students in basic mathematics according to the teachers. The test was administered in large-group settings within the usual fifty-minute class period. The lack of flexibility in the time permitted of each item of the test bothered some students and teachers. Some teachers would have preferred that the test be individually administered with a student having control over the time spent in responding to each item. Some students became frustrated when there was insufficient time to perform pencil-and paper computations more lengthy than necessary for the anticipated methods of solution. Although students were advised to attempt to solve the problems without using lengthy computations, many of the least prepared students adopted slow and tedious methods for solving the problems and hence could not

record a correct solution even if they could in fact have done so given unlimited time. However, changing the BMDI to an individually administered test with the student having control over the time spend per problem would almost certainly change the character of the measurements obtained and might not serve the best interests of the basic mathematics student. The present form of the BMDI was designed to measure both adeptness in computation, adroitness of organization of information, and depth of understanding of content. In a test without a time factor, students would have a higher tendency to use memorized but not understood procedures of problem solving or to use inefficient computational processes. One of the purposes of developmental mathematics programs is to prepare underprepared students to succeed in regular college courses. Thus, encouraging inefficient use of time may be detrimental to future success. If the determination of a student's strengths is not predicated on his ability to organize information and his agility of computation along with depth of understanding of content, then it appears that the information concerning these strengths is of dubious value in remediation. When administering the BMDI it appeared that the majority of students in each class had sufficient time to respond. However, items which needed more computational time are recognized in the Recommendations section of this chapter.

A majority of the instructors found the propensity-for-error-types profiles helpful in gaining insight into the number of students with potential reading problems and the number of students who tended

to choose random responses. The information that many students had lack of knowledge of content and used defective algorithms was an expected result.

Much written and most verbal responses received from the teachers indicated that the test information was applied to entire classes. This procedure conflicted with the purpose of the diagnostic instrument. The intended use of the student profiles was for the teacher to discuss content strengths and weaknesses with each individual student, showing him the types of errors he most consistently made, taking into consideration how the student perceived he had performed on each of the initial subtests of the BMDI.

The value of the student's perception of performance profile was considered to be of little instructional value by the teachers. Also, questionnaire responses showed lack of enthusiasm for the error-types profile. Therefore, it seems plausible to conclude that teachers did not use the error and perception profiles in the manner intended. This result may in part reflect the fact that on the average the students of this sample appeared to make realistic appraisals of each content subtest performance which may in turn have made the teachers insensitive to the less numerous cases with discrepant perceptions of performance.

DISCUSSION

While statistical outcomes from student responses indicated the goals of the BMDI were largely met given minor revisions (see

recommendations in this chapter), teachers reactions were somewhat negative. Teachers of basic mathematics in community colleges should be aware that these underprepared students often have learning disabilities. These learning disabilities may be of differing degrees and different types such as emotional problems, minimal brain dysfunctions, perception problems, or low intelligence (Lozak, Jefferson and Sutton, 1970). Although the basic mathematics teachers are usually hired as subject matter specialists, they are expected to primarily perform as learning disability specialists. However, most learning disability specialists would not have sufficient knowledge of mathematics to be a basic mathematics teacher. The solution to this dilemma would be for basic mathematics teachers to be trained in techniques of diagnosis of learning problems and in prescription of modes of remediation of learning problems.

The diversity of learning problems often encountered with basic mathematics students makes the individualized instructional approach better for these students (Moore, 1970). This approach demands the teacher become a manager of instruction rather than a presenter of facts and processes. Many basic mathematics teachers have no training in using individualized approaches to instruction. In the individualized setting no one mode of instruction is appropriate, neither is one type of text sufficient. The course content must be divided into singular, self-contained units which permit a variety of learning situations. Then, a test such as the BMDI would yield information

the instructor could use to inform the student of his content strengths and to design an individual course for remediation of weaknesses.

Arguments against this approach indicate that the basic mathematics teachers do not have time to produce the self-contained units or to develop parallel forms of tests. Furthermore, teachers claim that classes are too large and there is insufficient help available to give the student the attention he needs. Numerous books and articles have been published in the last five years responding to these arguments. In summary, they conclude that often teachers already have the necessary curriculum materials available. It is a matter of reorganizing the existing units and supplementing textbook presentations with other modes of presentation. When attempting to teach students on an individual basis, one must recognize that every student will not need individual attention from the teacher each class session. In some schools student tutors can assist in instruction. Team-teaching can also aid in producing a more equitable classtime workload. In summary, this discussion illustrates the need for investigation of the criteria used when assigning mathematics teachers to teach basic mathematics classes, for more individualization of instruction in basic mathematics classes, for additional training of basic mathematics teachers in the field of learning disabilities, for more flexability in teaching modes, and for support in terms of preparation time and teacher assistance in developing alternative modes of learning. Both administrators and teachers need to recognize that students in basic mathematics are not inexperienced. Granted these students have

weaknesses which must be remediated for future college success or for future employment, but they bring to the basic mathematics class some knowledge of mathematics and they should not be taught in a manner which assumes that they have had no previous exposure to the subject content or skills.

The basic mathematics teachers appeared eager to participate in the field study of the BMDI and several voiced the need for diagnostic instruments in arithmetic and beginning algebra. Yet many of the teachers found the amount of student information generated by the BMDI to be unwieldy. The seeming unwillingness of the instructors to attempt to interpret profile results can be attributed to the following factors:

1. Teachers are not well versed in the interpretation of test data. The test information they usually receive is normative data; hence, they are unaware of the correct usage of diagnostic information (Moore, 1970).

2. Emphasis in teacher education is seldom placed on the application of test results for improvement of instruction. If any attention is given to testing, it is usually directed toward ways to build a test. In mathematics, pencil-and-paper tests are encouraged.

3. The orientation of the basic mathematics teachers to the philosophy, goals, and results of the BMDI was not sufficient for the instructors to gain additional understanding of the students in the sample.

In most instances the instructors had access to each student's previous high school record, to at least one standardized test score,

and to the reason the counselor had recommended the student be placed in basic mathematics. It was not intended for the information of the BMDI to supplant available data, but rather to additionally refine the diagnosis of student weaknesses in basic mathematics. In some few cases teachers indicated that the BMDI seemed not to correlate well with presently used placement instruments and this outcome was viewed as a defect rather than as an opportunity to gain further information about the student. Further, many teachers gave evidence of being unaware of the absence of any instrument comparable to the BMDI and seemed unaware that correlation of BMDI results with normative test scores was inappropriate given the rationale for developing the BMDI.

It is not the intent of this discussion to criticize any community college that participated in the field study of the BMDI or any of the members of the faculties or administrations. Preceding comments were made to apprise anyone reading the study of the problems encountered when working with developmental mathematics students and for the need of support both in personnel and money for these developmental programs designed to accomplish the task of remediation of weaknesses in underprepared students.

RECOMMENDATIONS

From the previous discussion and the statistical results of the field study two sets of recommendations were deduced. The first list of recommendations pertains to improving the utilization of the BMDI by basic mathematics instructors while the second list recommends ways of improving the diagnostic instrument.

Recommendations Concerning Instructors

1. Basic mathematics instructors should be trained in the interpretation of diagnostic tests, in the analysis of errors made by students in mathematics, and in communicating test results to students.

2. Counselors and learning disability specialists should assist basic mathematics instructors in diagnosing, remediating and evaluating learning problems found in basic mathematics students.

3. Teachers of underprepared students in basic mathematics should be trained in determining modes of instruction, types of presentations, and applications of content which will serve to improve the students' understanding of mathematical content and skills.

4. Basic mathematics instructors must be apprised of suitable ways to communicate with basic mathematics students and to recognize the relationship between each student's self-image in light of his perceived strengths and weaknesses in basic mathematics.

5. Whenever the BMDI is administered to basic mathematics students, the instructors should be given a thorough orientation to the objectives of the test, rationale for the slide-tape presentation, the structure of the subtests, and the content of the subtests.

6. Instructors should be informed of the ways to adapt the BMDI student profiles to meet the objectives of their particular course sequences and in how to interrelate the four profile sheets produced on each student to establish a sequence of instruction to meet the needs of the individual student.

7. Counselors and instructors should be encouraged to use the BMDI as an additional diagnostic measure of a student's mathematical abilities and not as a single placement instrument.

The above seven recommendations are not based upon statistical evidence. They are based on observations made by the author during and immediately after the field study.

Recommendations for Improvement of the BMDI

All the following recommendations were determined from the statistical analysis of the BMDI.

1. An answer sheet should be designed with items listed vertically. Printing on the answer sheet should be of a type easily read in a classroom with lighting dimmed sufficiently for the students to view high-contrast slides.

2. Scoring mats should be produced for hand scoring of the BMDI by instructors when computer scoring is not feasible.

3. A common factor analysis of the error-type responses obtained in the sample should be performed to determine the number of unique factors being generated by student errors. These unique factors should then be identified as new error types and new keys be developed for computing student error-type scores. The error-type profile sheet would then have to be redesigned.

4. All error responses not chosen by at least ten percent of the sample who made errors should be removed. Replacement of responses not meeting the minimum criterion should be done one of the following

ways: (1) Replace the rejected response with a "none of these" response if there is not already a "none of these" response in the item. (2) Replace the rejected response with another response keyed to an error-type the same as the one rejected unless this item has all its error responses keyed to the same error-type. (3) Replace the rejected response with an error response from another error-type.

5. All error responses correlating less than .20 with the error-type total score should be replaced using the same three alternatives listed in Recommendation 4.

6. Four items should be deleted from the BMDI because they failed to meet the item-subtest criteria. These items were 6, 9, 10, 37.

7. Both the initial subtest and the supplementary subtest profiles of student strengths and weaknesses should be retained as they permit the BMDI to more closely coincide with course unit sequencing.

8. The number of items omitted within each subtest should be reported on the subtest profile sheets.

9. Items 5, 26, 37, and 53 should each have the solution time increased by five seconds. Items 21, 23, 29, 34, 35, 38, 45, 46, 50, and 62 each have the solution time increased by ten seconds.

10. Item 2 should be changed to: "There are three groups shown below. (Group C contains twenty-three dollar signs.) . . ." because students had difficulty counting the elements in Group C and not the elements in Group A.

11. Item 60 should be changed to: "$4.00 would be 25% of how many dollars?" to avoid the possibility of the student being able to guess the correct response from one of the numerals in the item.

12. Consideration should be given to producing a second diagnostic instrument using the same methodology and design as the BMDI covering mathematical content found in most beginning algebra and intermediate algebra courses in community colleges.

BIBLIOGRAPHY

Beal, Jack. "An Analysis of Remedial Mathematics Programs in Junior and Community Colleges." Research in Education, October, 1970. (ED 043 335)

Braswell, James S. Mathematics Tests Available in the United States. Washington, D.C.: National Council of Teachers of Mathematics, 1972.

Brown, Donald J. Appraisal Procedures in the Secondary Schools. Englewood Cliffs, N.J.: Prentice-Hall, 1970.

Brown, Frederick G. Measurement and Evaluation. Itasca, Ill.: F. E. Peacock Publishers, Inc., 1971.

Brueckner, Leo J. Diagnostic Tests and Self-Helps in Arithmetic. Monterey, Calif.: McGraw-Hill, 1955.

Buros, Oscar K. (ed.). The Mental Measurements Yearbook series. Highland Park, N.J.: Gryphon Press, 1953, 1959, 1965, 1972.

College Entrance Examination Board. Comparative Guidance and Placement Test. New York: CEEB, 1972.

Connally, A. J., W. Nachtman, and E. M. Prichett. KeyMath Diagnostic Arithmetic Test. Circle Pines, Minn.: American Guidance Service, 1971.

Cross, K. Patricia. Beyond the Open Door. San Francisco, Calif.: Jossey-Bass, 1971

Cross, K. Patricia. "The New Learners." Change. Vol. 5, No. 1, Frbruary, 1973, pp. 31-34.

Curriculum Committee of the New York State Mathematics Association of Two Year Colleges. Remedial Mathematics Newsletter. Vol. 1, No. 2, March, 1975, pp. 9-11.

Ferguson, G. A. Statistical Analysis in Psychology and Education, Third edition. New York: McGraw-Hill, 1971.

Frary, R. B. "A User's Guide to the VPI & SU Test Scoring and Analysis System." Blacksburg, Virginia: Learning Resources Center, 1974. (Mimeographed.)

French, J. W., and W. B. Michael. Standards for Educational and Psychological Tests and Manuals. Washington, D.C.: American Psychological Association, 1966.

Gessel, John. Prescriptive Mathematics Inventory. Monterey, Calif.: McGraw-Hill, 1971.

Gordon, Edmund M., and Doxey A. Wilkersen. Compensatory Education for the Disadvantaged. New York: College Entrance Examination Board, 1966.

Guilford, J. P. Fundamental Statistics in Psychology and Education. New York: McGraw-Hill, 1956.

Junge, Charlotte W. "Adjustment of Instruction (Elementary School)." The Slow Learner in Mathematics, Thirty-fifth Yearbook. Washington, D.C.: The National Council of Teachers of Mathematics, 1972.

Losak, J. G. "A Pilot Study Related to the Identification, Placement and Curriculum Developed for Academically Underprepared Students." Research in Education, November, 1970. (ED 014 585)

Losak, J. G. "The Academically Underprepared Student." New Directions for Community Colleges. Vol. 3, Autumn, 1973, pp. 35-46.

Losak, J. G., T. Jefferson, and C. Sutton. "Psychological Characteristics of Underprepared Students." Research in Education, November, 1970. (ED 041 577)

Menne, Joy M., and John W. Menne. "The Relative Efficiency of Bimodal Presentation as an Aid to Learning." AV Communication Review, Vol. 20, No. 2, Summer, 1972, pp. 170-180.

Moore, William, Jr. Against the Odds. San Francisco, Calif.: Jossey-Bass, 1970.

Roberts, Gerhard H. "The Failure Strategies of Third Grade Arithmetic Pupils." The Arithmetic Teacher, Vol. 15, May, 1968, pp. 442-446.

Roueche, John E. Salvage, Redirection or Custody? Remedial Education in the Community Junior College. Washington, D.C.: American Association of Junior Colleges, 1968.

Roueche, John E. A Modest Proposal; Students Can Learn. San Francisco, Calif.: Jossey-Bass, 1972.

Roueche, John E., and R. W. Kirk. Catching Up: Remedial Education. San Francisco, Calif.: Jossey-Bass, 1973.

Scacht, Elmer J. "A Study of the Mathematical Errors of Low Achievers in Elementary School Mathematics." Unpublished Doctor's dissertation, Wayne State University, Ann Arbor, Michigan, 1966.

Sheldon, M. Stephen. "Entrance and Placement Testing for the Junior College." Research in Education, December, 1970. (ED 044 110)

Spache, G. D. Diagnostic Reading Scales (Examiners Manual), Revised Edition. New York: McGraw-Hill, 1971.

Stein, S. K. "Mathematics for the Captured Student." The American Mathematical Monthly, Vol. 79, No. 9, November, 1972, pp. 1023-1032.

APPENDIX A

Student Perception of Subtest Performance Response Frame of the BMDI

STUDENT PERCEPTION OF SUBTEST PERFORMANCE

You have just completed the subtest on _____.
From the four sentences below choose the one which best describes how you feel you did on this part of the test.

(1) I knew how to do almost all of the problems, and I believe I got almost all of them right.

(2) I may have made a few mistakes, but I believe I did quite well.

(3) Although I could not do some of the problems, I think I got at least half of them right.

(4) I probably got less than half of the problems right on this part of the test.

APPENDIX B

Student Profiles

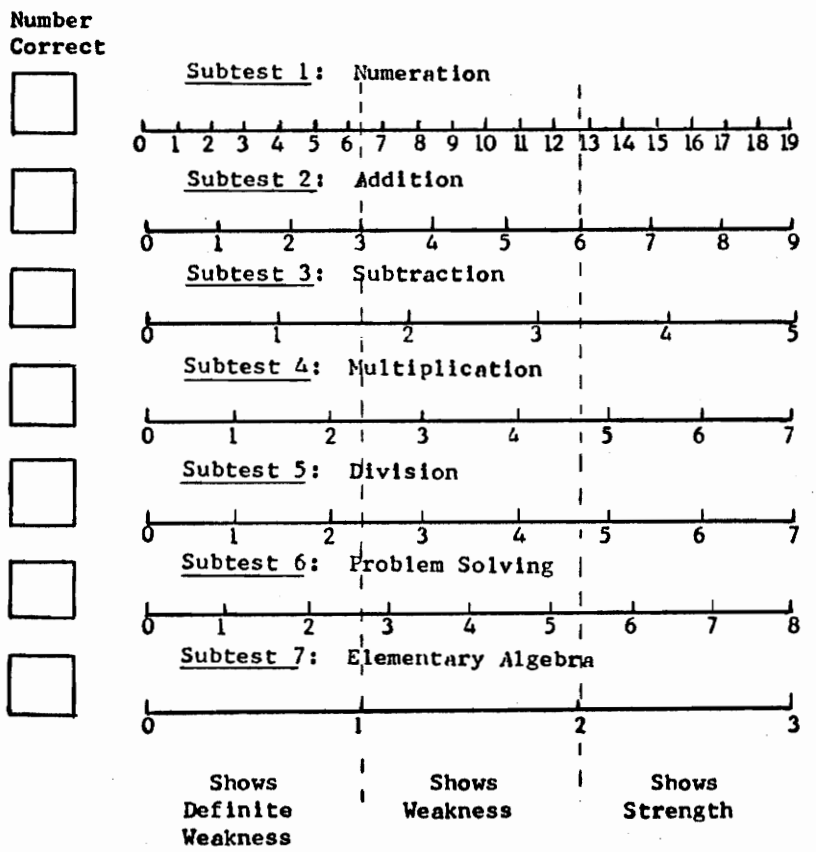
SUBTEST PROFILE SHEET

Strengths and Weaknesses

Directions:

Place each of the subtest mats over the optical scanning form and record the number of correct responses in the box on the left-hand side of this profile sheet. Place a dot on the scale on the right of the box which corresponds to the number in the box. When all seven subtests have been recorded, connect the points to obtain the student's profile. Look at the bottom of the page for the interpretation of the subtest scores; they will be: shows definite weakness, shows weakness, or shows strength.

Name of Student _____ I.D. Number _____



SUPPLEMENTAL PROFILE SHEET

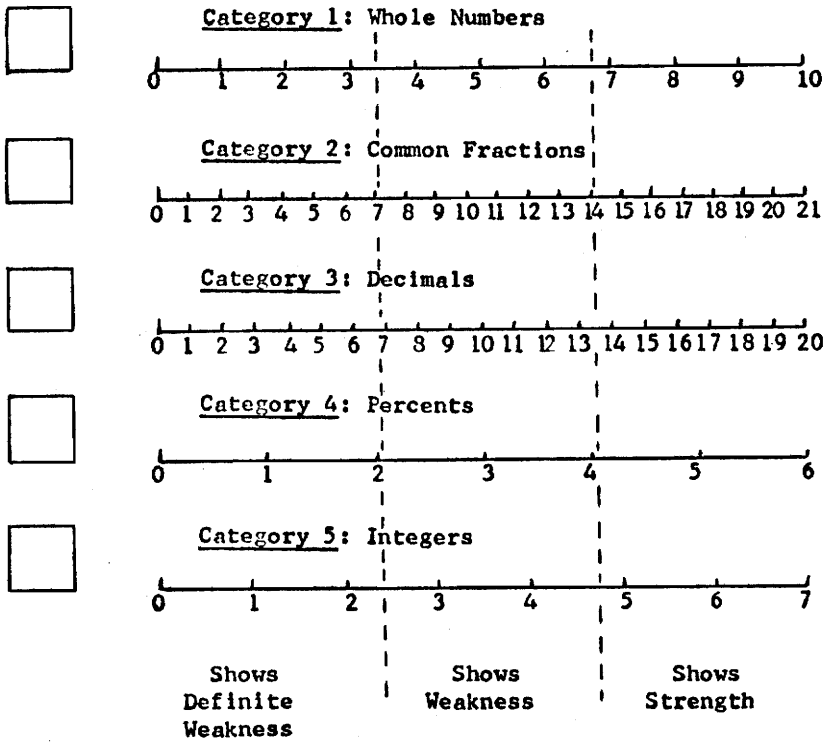
Working with Numerals

Directions:

Place each of the supplemental mats over the optical scanning form and record the number of correct responses in each category in the boxes on the left-hand side of this profile sheet. Place a dot on the scale to the right of the box corresponding to the number in the box. When all five scales have been marked, connect the dots to obtain the student's profile. Look at the bottom of this page for the interpretation of the student's ability to work with numerals.

Name of Student _____ I.D. Number _____

Number Correct



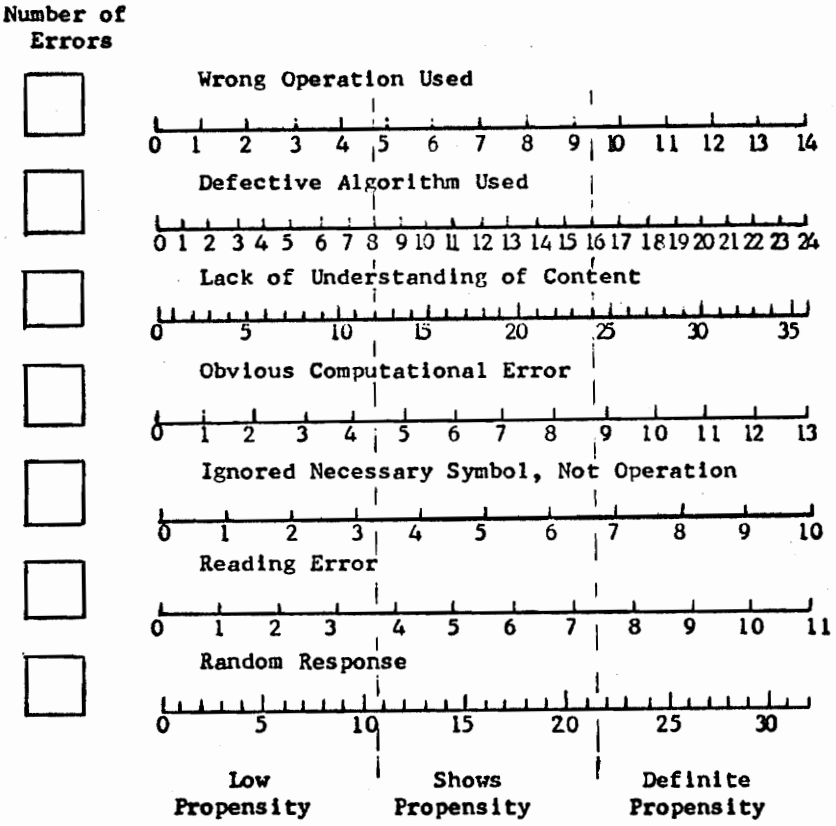
E R R O R P R O F I L E S H E E T

Propensity for Error Types

Directions:

Place each of the error mats over the optical scanning form and record the number of errors of each type made in the box on the left-hand side of this profile sheet. Place a dot on the scale on the right of the box corresponding to the number in the box. When all seven error types have been recorded, connect the points to obtain the student's profile. Look at the bottom of the page for the interpretation of the student's error propensity.

Name of Student _____ **I.D. Number** _____

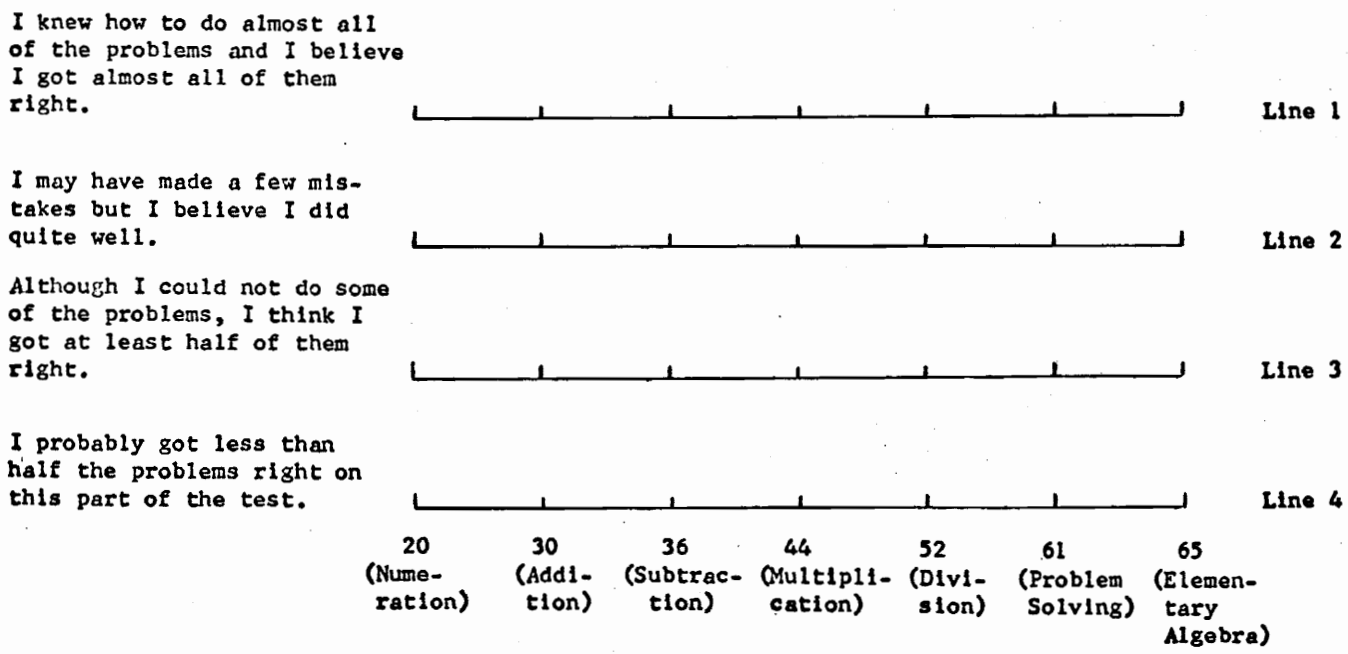


STUDENT PERCEPTION OF SUBTEST PERFORMANCE

Directions:

The numbers across the bottom of this sheet correspond to item numbers on the optical scanning form. The numbers on the right of this sheet correspond to the student's indicated response on the optical scanning form. Place a small X on the line corresponding to the student's response on the indicated item. For example: If the student recorded a 3 on item 20, then place an X on line 3 directly over the 20 at the bottom of this sheet. Connect the X's to obtain the student's perception of subtest performance profile. Look to the left side of this sheet for interpretation of each subtest performance as the student perceives it. It would be beneficial to compare these perceptions to the student's actual performance as recorded on the SUBTEST PROFILE SHEET.

Name of Student _____ I.D. Number _____

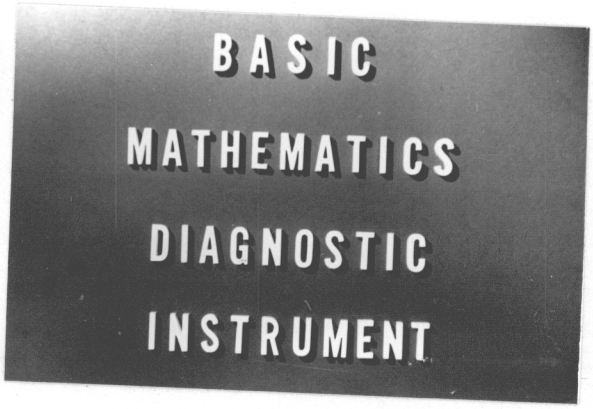


APPENDIX C

Reproduction of the BMDI

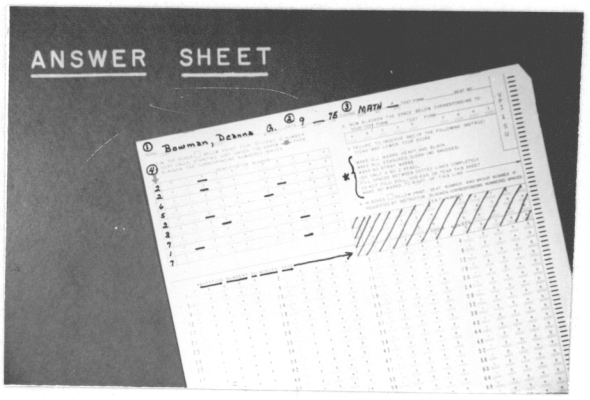
A. Photographic Reproduction of Slides
B. Transcript of Tape
C. Error Diagnosis

Frame Number 1



Script: This test is called the Basic Mathematics Diagnostic Instrument. It is designed to find out how much you already know about arithmetic and beginning algebra. It is composed of seven parts. It covers skills you may have mastered in studying different kinds of numbers; in addition, subtraction, multiplication, and division, and in problem solving. You will find some of the problems rather easy because you have already mastered them. There may be some problems not so easy and your teacher will later work with you to master them. You should have at your desk a Number 2 pencil, one sheet of clean paper to use as "scratch" paper, and one answer sheet. You should have your Social Security number handy if you do not already know it.

Frame Number 2



Script: This is a picture of your answer sheet. On your answer sheet, first, print your name in the top left as illustrated. (Pause). Second, put today's date in the manner shown. (Pause). Third, put your class name and number; for example, Math .01. (Pause). Fourth, on the left side of the answer sheet under the large red arrow you will see running vertically boxes in which to print your Social Security number. Print your Social Security number with the first number in the top box. (Pause). Now between the dotted lines to the right of each number carefully blacken in the slot corresponding to the number you printed on the left. (Pause). This is all you need to do in the top portion of your answer sheet.

Here are the directions for marking the answers to the test questions. Listen carefully.

Make all marks heavy and black.

Make all erasures clean and smudgeless.

Make no stray marks.

Use only a Number 2 pencil.

Fill spaces between the dotted lines completely.

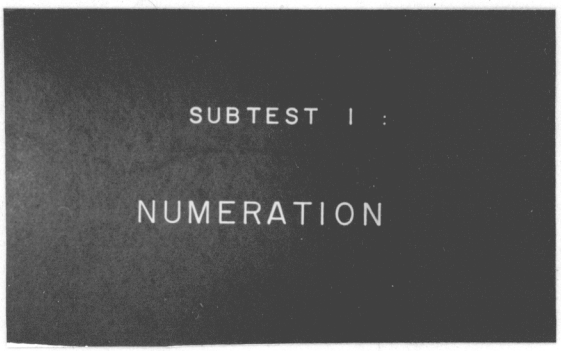
Do not fold, dog-ear, or tear your answer sheet.

The Basic Mathematics Diagnostic Instrument is a multiple-choice test. You will answer each question by marking your answer sheet.

If you need to do some pencil-and-paper work, please do this on your scratch paper. Try to think through the problem without using your scratch paper. You will usually have five possible answers to each problem. If you can eliminate some of the answers and can't decide between two answers then guess. But, if you have no idea of the correct answer, please leave it blank. If you leave a question blank this means that you will not put a mark in any of the slots for that question. Notice that the question numbers run across the answer sheet. You will go from left to right for questions one through four, come back to the left for number five through eight, etc. until you complete the test.

You are now ready to begin the test. You will see each question on the screen and you can listen as each question is read to you.

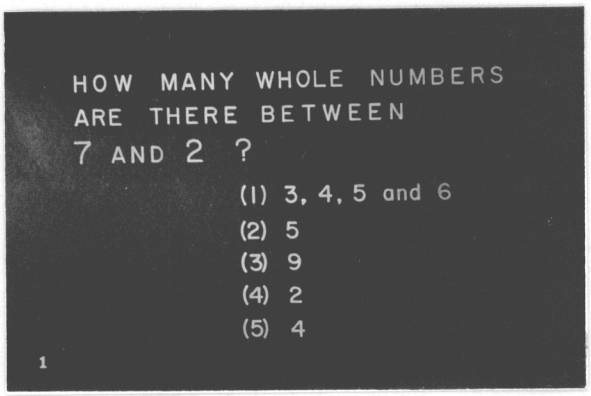
Frame Number 3



Script: The first part of the Basic Mathematics Diagnostic Instrument is called Numeration. We wish to know what you already know about different kinds of numbers.

Subtest 1 -- Numeration

Frame Number 4



Script: Locate the red number one on your answer sheet just below where you printed your Social Security Number. This is question number

one. How many whole numbers are there between seven and two? You will mark either slot one, two, three, four or five to indicate the response you believe to be correct. (Pause). Notice that there is a small number located in the bottom left corner of this frame. A small number will be in the same place on each question frame to indicate where you should be on your answer sheet.

Error Diagnosis:

(1) Reading

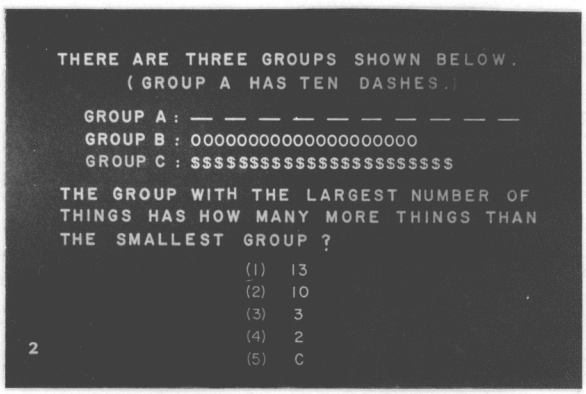
(2) Wrong operation used. (Subtracted instead of counting.)

(3) Random response (Impulsivity)

(4) Lack of understanding of content (Thought even numbers were whole numbers.)

(5) Correct response

Frame Number 5



Script: Question number two. There are three groups shown below. Group A has ten dashes. The group with the largest number of things has how many more things than the smallest group? (Pause).

Error Diagnosis:

(1) Correct response

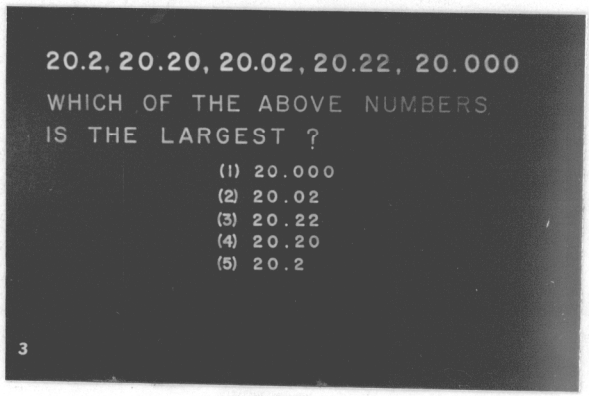
(2) Lack of understanding of content (Compared wrong groups, A & B.)

(3) Lack of understanding of content (Used visual appearance of A & B.)

(4) Lack of understanding of content (Does not know meaning of "size".)

(5) Reading

Frame Number 6



Script: Question number three. Which of the above numbers is the largest? (Pause).

Error Diagnosis:

(1) Lack of understanding of content (Used visual appearance and ignored decimals.)

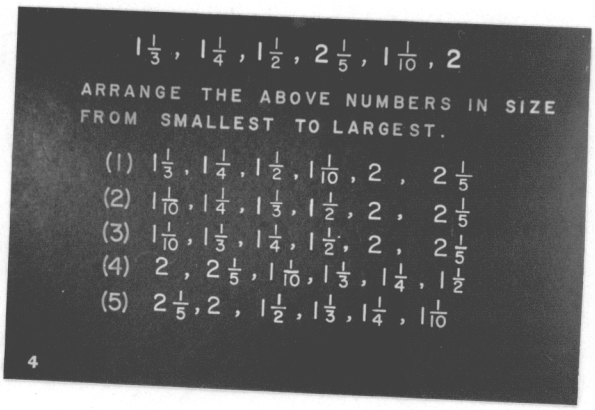
(2) Lack of understanding of content (Has inaccurate knowledge of zero as a placeholder.)

(3) Correct response

(4) Lack of understanding of content (Has inaccurate knowledge of zero as a placeholder.)

(5) Random response (Impulsivity)

Frame Number 7



Script: Question four. Arrange the above numbers in size from smallest to largest. (Pause).

Error Diagnosis:

(1) Random response (Impulsivity)

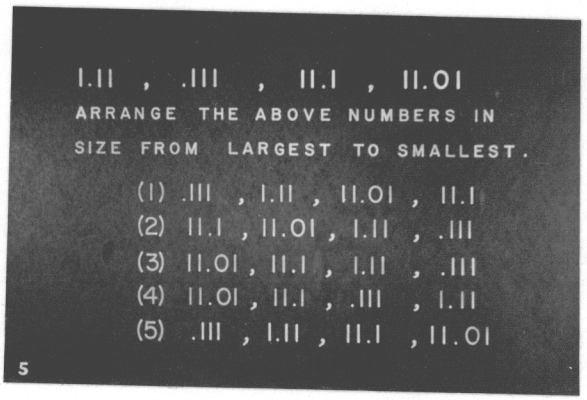
(2) Correct response

(3) Lack of understanding of content (Cannot compare proper fractions.)

(4) Lack of understanding of content (Cannot compare mixed numbers and had wrong order.)

(5) Reading (Placed in wrong order.)

Frame Number 8



Script: Question number five. Remember you move back to the left side of your answer sheet. Arrange the above numbers in size from largest to smallest. (Pause).

Error Diagnosis:

(1) Reading (Placed in wrong order.)

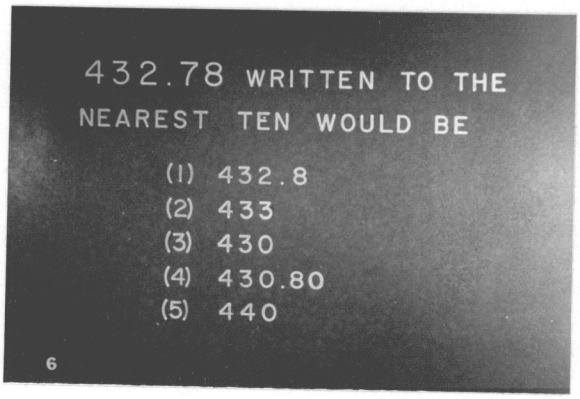
(2) Correct Response

(3) Lack of understanding of content (Used visual appearance and has inaccurate knowledge of zero as a placeholder.)

(4) Random response (Guessing.)

(5) Reading (Placed in wrong order and inaccurate knowledge of zero as a placeholder.)

Frame Number 9



Script: Four hundred thirty-two and seventy-eight hundredths written to the nearest ten would be?

Error Diagnosis:

(1) Lack of understanding od content (Rounded to the nearest tenth.)

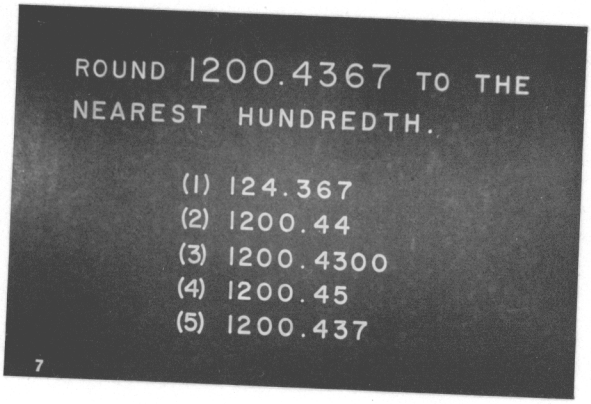
(2) Lack of understanding of content (Does not know place values.)

(3) Correct response

(4) Defective algorithm used (Rounded to the nearest tens and tenths.)

(5) Defective algorithm used (Rounded upward when less than 5.)

Frame Number 10



Script: Round one thousand two hundred and four thousand, three hundred sixty-seven ten-thousandths to the nearest hundredth.

Error Diagnosis:

(1) Lack of understanding of content (Ignored zero as a placeholder.)

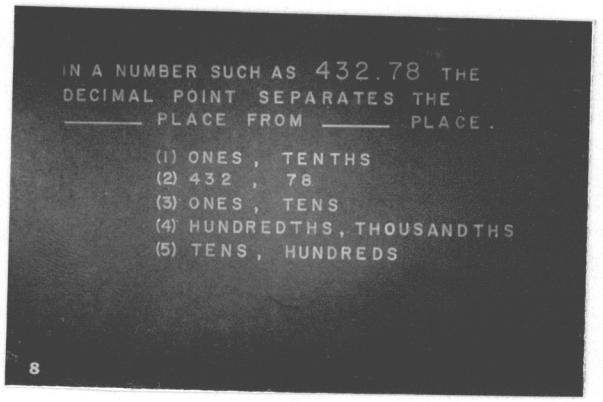
(2) Correct response

(3) Defective algorithm used (Did not round upward when greater than five.)

(4) Defective algorithm used (Replaced 3 with a 5 in hundredths position.)

(5) Lack of understanding of content (Does not know place values.)

Frame Number 11



Script: Fill in the blanks. In a number such as four hundred thirty-two and seventy-eight hundredths the decimal point separates the blank place from the blank place.

Error Diagnosis:

(1) Correct response

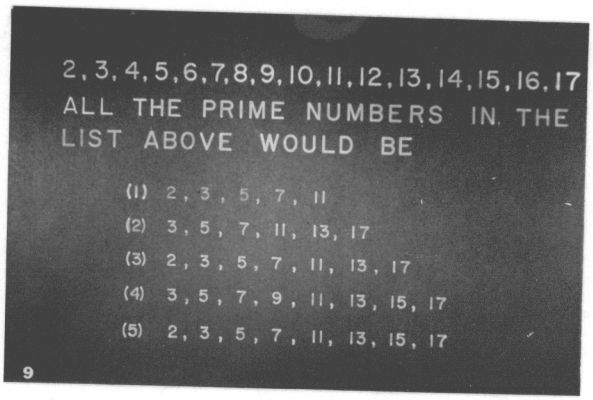
(2) Random response (Impulsivity)

(3) Lack of understanding of content (Confused tenths and tens.)

(4) Lack of understanding of content (Does not know place values.)

(5) Lack of understanding of content (Does not know place values.)

Frame Number 12



Script: Question nine. Move back to the left on your answer sheet. All the prime numbers in the list above would be?

Error Diagnosis:

(1) Lack of understanding of content (Has inaccurate knowledge of primes.)

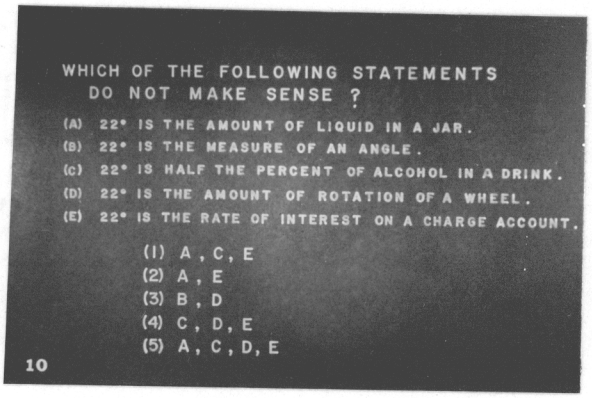
(2) Lack of understanding of content (Has inaccurate knowledge of primes.)

(3) Correct response

(4) Lack of understanding of content (Confusing odd numbers with prime numbers.)

(5) Lack of understanding of content (Has incorrect knowledge of primes.)

Frame Number 13



Script: Which of the following statements do not make sense?

A. Twenty-two degrees is the amount of liquid in a jar.

B. Twenty-two degrees is the measure of an angle.

C. Twenty-two degrees is half the percent of alcohol in a drink.

D. Twenty-two degrees is the amount of rotation of a wheel.

E. Twenty-two degrees is the rate of interest on a charge account.

Error Diagnosis:

(1) Correct response

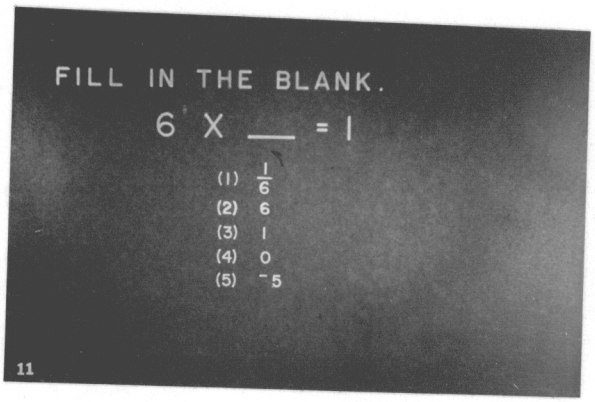
(2) Random response (Impulsivity)

(3) Reading

(4) Lack of understanding of content (Has incomplete knowledge of the use of degrees.)

(5) Lack of understanding of content (Has incomplete knowledge of the use of degrees.)

Frame Number 14



Script: Fill in the blank. Six times blank equals one.

Error Diagnosis:

(1) Correct response

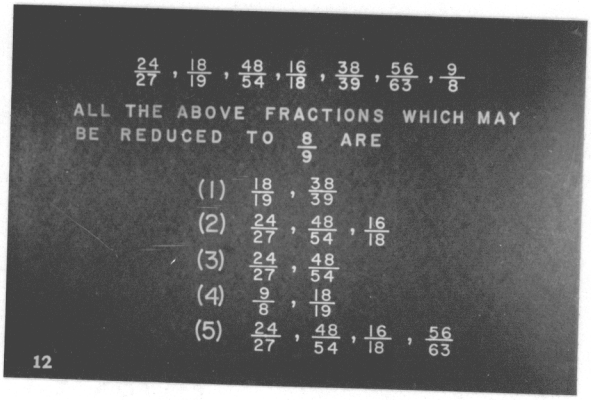
(2) Wrong operation used (Division instead of multiplication.)

(3) Lack of understanding of content (Confusing multiplicative identity and multiplicative inverse.)

(4) Lack of understanding of content (Unable to compute with zero.)

(5) Wrong operation used (Added instead of multiplied.)

Frame Number 15



Script: All the above fractions which may be reduced to eight-ninths are?

Error Diagnosis:

(1) Lack of understanding of content (Used cancellation process incorrectly.)

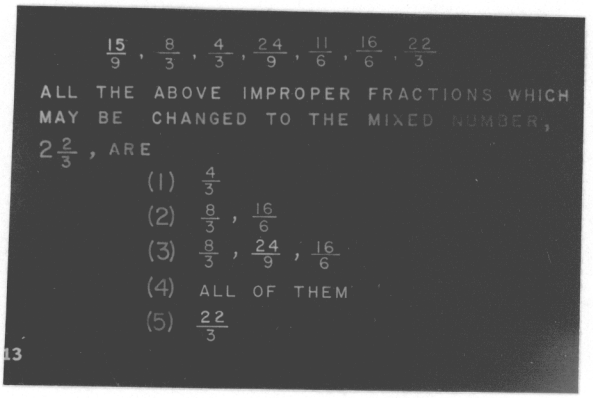
(2) Obvious computational error (Factored one fraction incorrectly.)

(3) Random response (Impulsivity)

(4) Lack of understanding of content (Doesn't know fractions.)

(5) Correct response

Frame Number 16



Script: All the above improper fractions which may be changed to the mixed number two and two-thirds are?

Error Diagnosis:

(1) Defective algorithm used (Added whole number and numerator.)

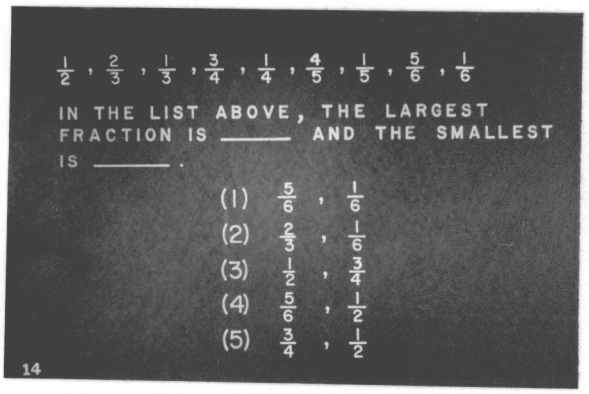
(2) Obvious computational error (Dividing 9 into 24.)

(3) Correct response

(4) Reading

(5) Defective algorithm used (Juxtaposed whole number and numerator.)

Frame Number 17



Script: Fill in the blanks. In the list above the largest fraction is blank and the smallest fraction is blank.

Error Diagnosis:

(1) Correct response

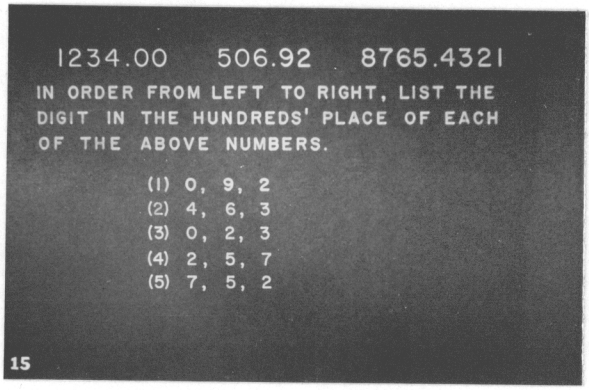
(2) Lack of understanding of content (Cannot compare unlike fractions.)

(3) Random response (Impulsivity)

(4) Lack of understanding of content (Cannot compare fractions with unlike denominators.)

(5) Lack of understanding of content (Cannot compare fractions.)

Frame Number 18



Script: In order from left to right, list the digit in the hundreds place of each of the above numbers.

Error Diagnosis:

(1) Lack of understanding of content (Does not know place values.)

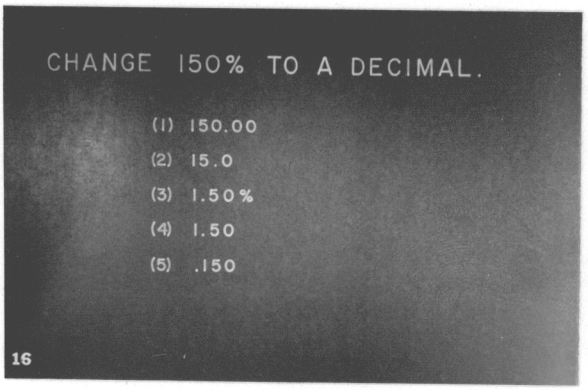
(2) Lack of understanding of content (Does not know place values.)

(3) Lack of understanding of content (Confusing hundreds with hundredths.)

(4) Correct response

(5) Reading

Frame Number 19



Script: Change one hundred fifty percent to a decimal.

Error Diagnosis:

(1) Ignored necessary symbol, not an operation (%)

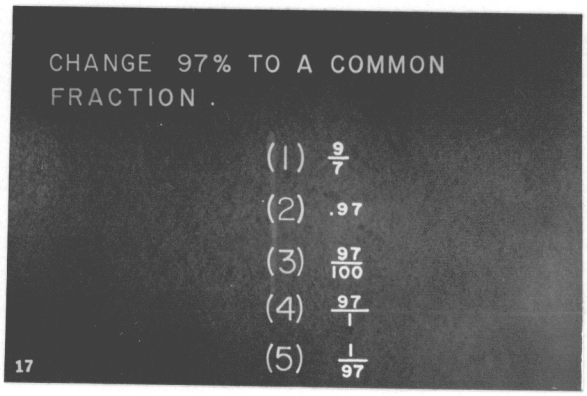
(2) Defective algorithm used (Moved one place to left.)

(3) Random response (Impulsivity)

(4) Correct response

(5) Defective algorithm used (Moved all the way to the left.)

Frame Number 20



Script: Change ninety-seven percent to a common fraction.

Error Diagnosis:

(1) Random response (Guessing)

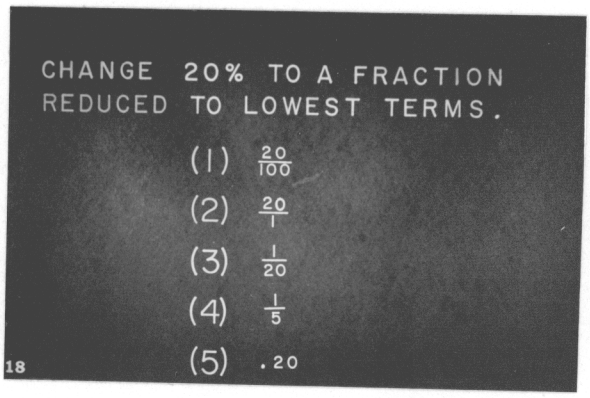
(2) Reading

(3) Correct response

(4) Ignored necessary symbol, not an operation (%)

(5) Lack of understanding of content (Does not know the meaning of %.)

Frame Number 21



Script: Change twenty percent to a fraction reduced to lowest terms.

Error Diagnosis:

(1) Reading

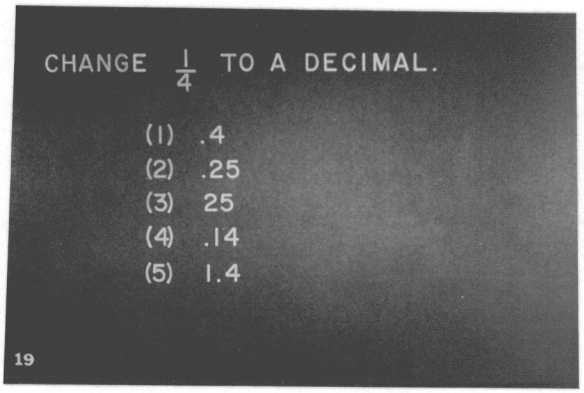
(2) Ignored necessary symbol, not an operation (%)

(3) Lack of understanding of content (Does not know the meaning of %.)

(4) Correct response

(5) Reading

Frame Number 22



Script: Change one-fourth to a decimal.

Error Diagnosis:

(1) Defective algorithm used (Made denominator decimal.)

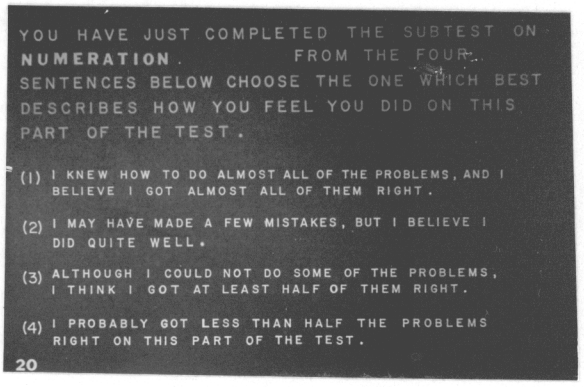
(2) Correct response

(3) Ignored necessary symbol, not operation (Forgot decimal in answer.)

(4) Defective algorithm used (Juxtaposed numerator and denominator.)

(5) Defective algorithm used (Juxtaposed numerator and denominator and placed decimal between.)

Frame Number 23



Script: You have just completed the subtest on numeration. From the four sentences below choose the one which best describes how you feel you did on this part of the test. Black in either slot 1, 2, 3 or 4 on question 20.

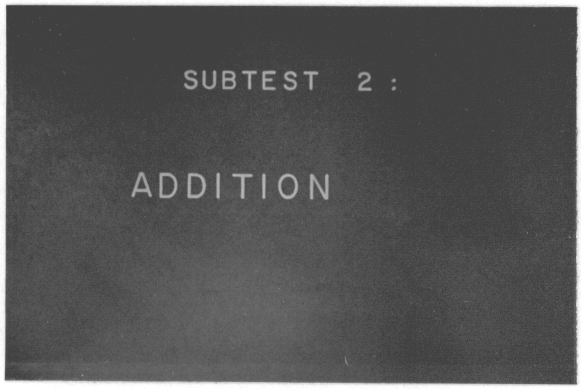
Number one, I knew how to do almost all of the problems and I believe I got almost all of them right.

Number two, I may have made a few mistakes but I believe I did quite well.

Number three, Although I could not do some of the problems, I think I got at least half of them right.

Number four, I probably got less than half of the problems right on this part of the test.

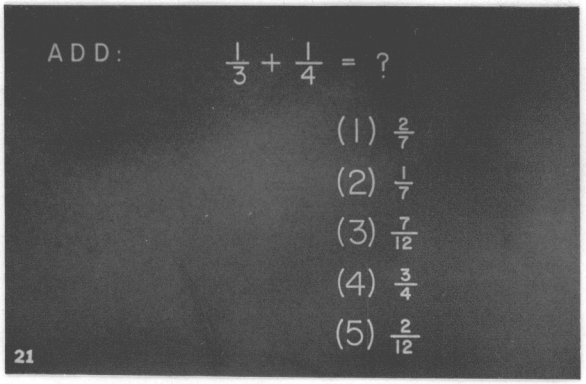
Frame Number 24



Script: We are on subtest number two on addition.

Subtest 2 -- Addition

Frame Number 25



Script: Add: one-third plus one-fourth equals?

Error Diagnosis:

(1) Defective algorithm used (Added numerator and numerator, denominator and denominator.)

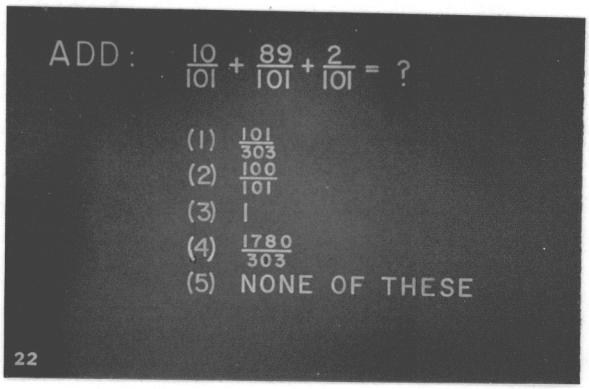
(2) Defective algorithm used (Multiplied numerators, added denominators.)

(3) Correct response

(4) Random response (Impulsivity)

(5) Defective algorithm used (Added numerators, multiplied denominators.)

Frame Number 26



Script: Add: ten over one hundred-one, plus eighty-nine over one hundred-one, plus two over one hundred-one, equals?

Error Diagnosis:

(1) Defective algorithm used (Added numerators and denominators.)

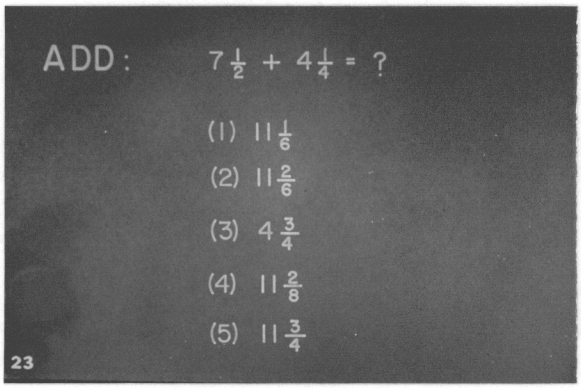
(2) Obvious computational error (Added incorrectly.)

(3) Correct response

(4) Defective algorithm used (Multiplied numerators and added denominators.)

(5)

Frame Number 27



Script: Add: seven and one-half plus four and one-fourth equals?

Error Diagnosis:

(1) Defective algorithm used (Addition of unlike fractions, multiplied numerators and added denominators.)

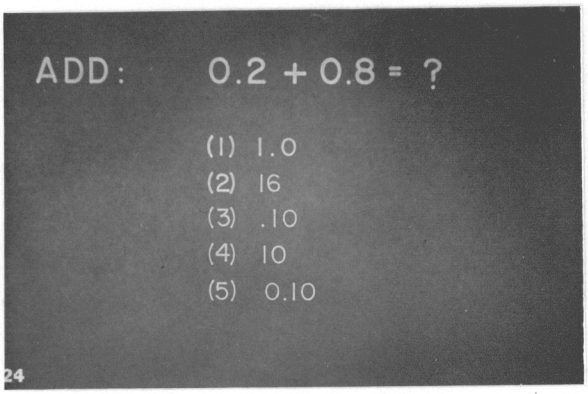
(2) Defective algorithm used (Addition of unlike fractions, added numerators and denominators.)

(3) Random response (Impulsivity)

(4) Defective algorithm used (Addition of unlike fractions, added numerators and multiplied denominators.)

(5) Correct response

Frame Number 28



Script: Add: two tenths plus eight tenths equals?

Error Diagnosis:

(1) Correct response

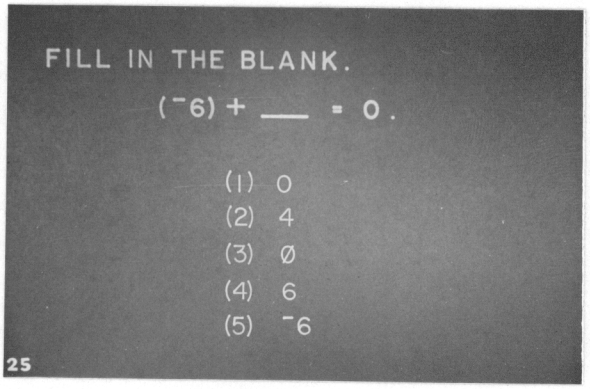
(2) Wrong operation used (Tried to multiply instead of add.)

(3) Lack of understanding of content (Does not know place values of the role of the decimal point.)

(4) Ignored necessary symbol, not operation (Decimal point in answer.)

(5) Lack of understanding of content (Does not know place values and confused with carrying across the decimal point.)

Frame Number 29



Script: Fill in the blank. Negative six plus blank equals zero?

Error Diagnosis:

(1) Lack of understanding of content (Confusing additive identity and additive inverse.)

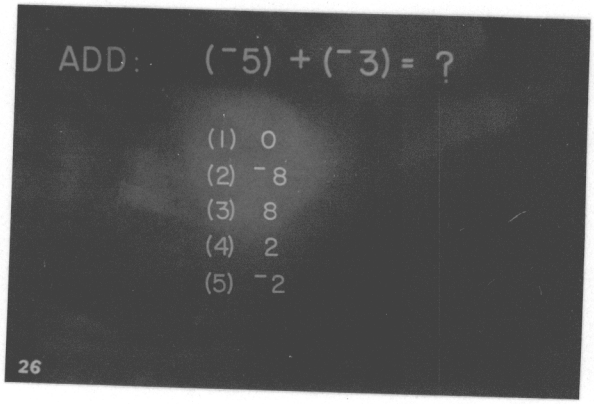
(2) Random response (Guessing)

(3) Random response (Guessing)

(4) Correct response

(5) Wrong operation used (Subtraction for addition.)

Frame Number 30



Script: Add: negative five plus negative three equals?

Error Diagnosis:

(1) Random response (Guessing)

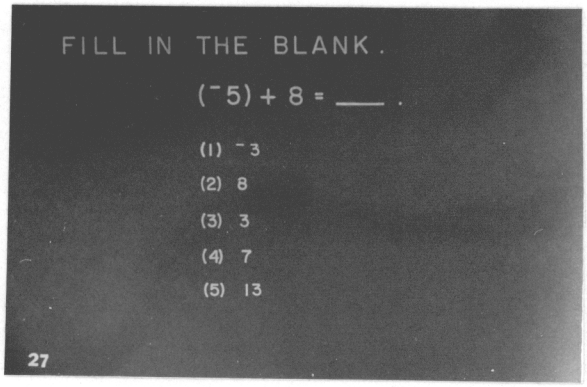
(2) Correct response

(3) Ignored necessary symbol, not operation (Forgot minus sign in answer.)

(4) Wrong operation used (Tried to subtract and ignored signs.)

(5) Wrong operation used (Subtraction for addition.)

Frame Number 31



Script: Fill in the blank. Minus five plus eight equals blank?

Error Diagnosis:

(1) Ignored necessary symbol, not operation (Put a minus sign in answer when not necessary.)

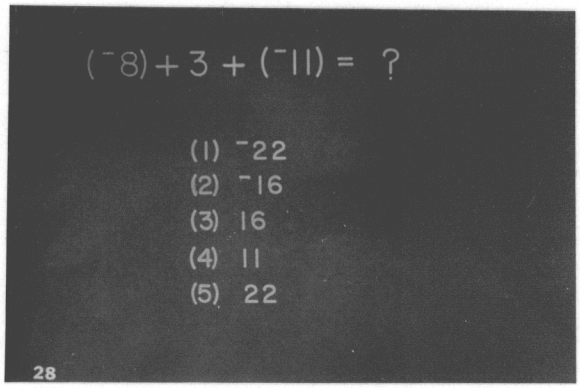
(2) Random response (Guessing)

(3) Correct response

(4) Random response (Guessing)

(5) Ignored necessary symbol, not operation (Ignored minus sign.)

Frame Number 32



Script: Minus eight plus three plus minus eleven equals?

Error Diagnosis:

(1) Lack of understanding of content (Changed all positives to negatives.)

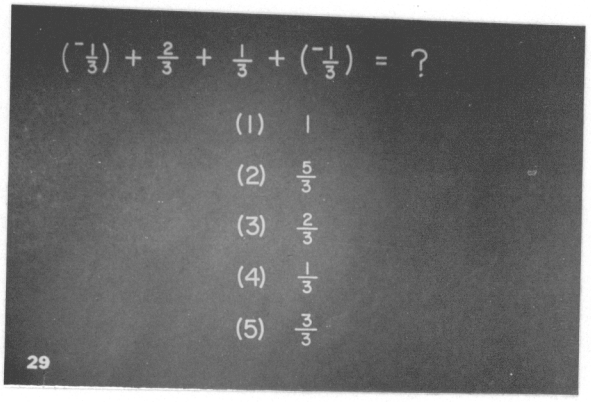
(2) Correct response

(3) Ignored necessary symbol, not operation (Forgot sign in answer.)

(4) Random response (Impulsivity)

(5) Lack of understanding of content (Ignored all negative signs.)

Frame Number 33



Script: Minus one-third plus two-thirds plus one-third plus minus one-third equals?

Error Diagnosis:

(1) Lack of understanding of content (Cannot add rational numbers.)

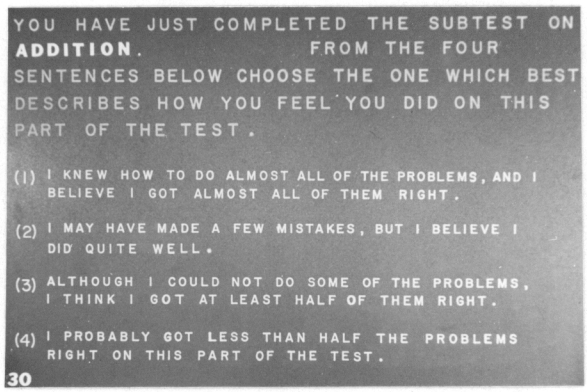
(2) Lack of understanding of content (Ignored all minus signs.)

(3) Defective algorithm used (Forgot one of the fractions.)

(4) Correct response

(5) Lack of understanding of content (Cannot add or simplify rational numbers.)

Frame Number 34



Script: You have just completed the subtest on addition. From the four sentences below choose the one which best describes how you feel you did on this part of the test.

Number one, I knew how to do almost all of the problems and I believe I got almost all of them right.

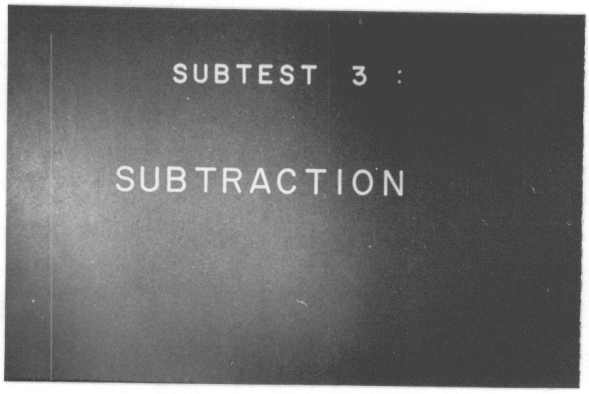
Number two, I may have made a few mistakes but I believe I did quite well.

Number three, Although I could not do some of the problems, I think I got at least half of them right.

Number four, I probably got less than half of the problems right on this part of the test.

You will notice that these are the same responses as at the end of the last subtest. You will see them again.

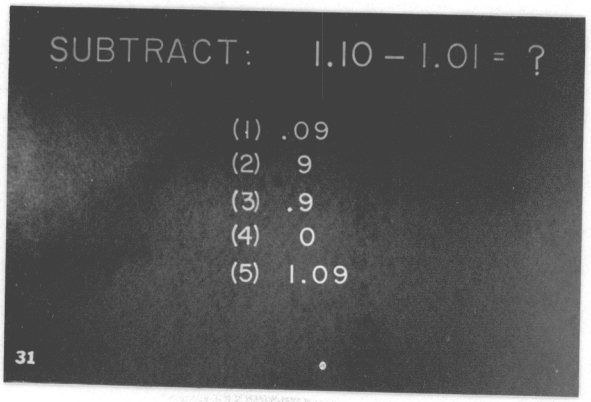
Frame Number 35



Script: We are now on subtest number three: Subtraction.

Subtest 3 -- Subtraction

Frame Number 36



Script: Subtract: one and ten hundredths minus one and one hundredth equals?

Error Diagnosis:

(1) Correct response

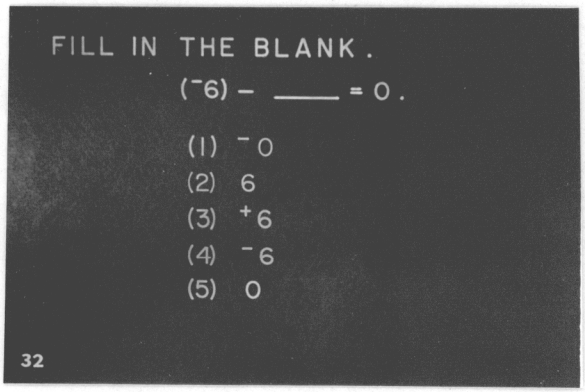
(2) Lack of understanding of content (Removed all decimals.)

(3) Lack of understanding of content (Ignored zero as a placeholder.)

(4) Lack of understanding of content (Ignored zero as a placeholder.)

(5) Obvious computational error (Forgot to subtract units.)

Frame Number 37



Script: Fill in the blank. Minus six minus blank equals zero.

Error Diagnosis:

(1) Random response (Impulsivity)

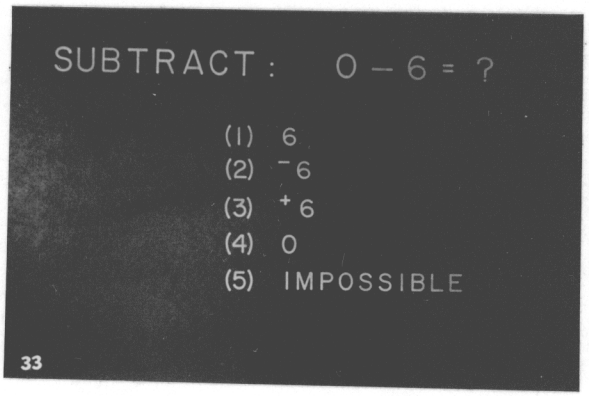
(2) Lack of understanding of content (Does not know how to subtract integers.)

(3) Lack of understanding of content (Does not know how to subtract integers.)

(4) Correct response

(5) Random response (Impulsivity)

Frame Number 38



Script: Subtract: zero minus six equals?

Error Diagnosis:

(1) Lack of understanding of content (Does not know how to subtract integers.)

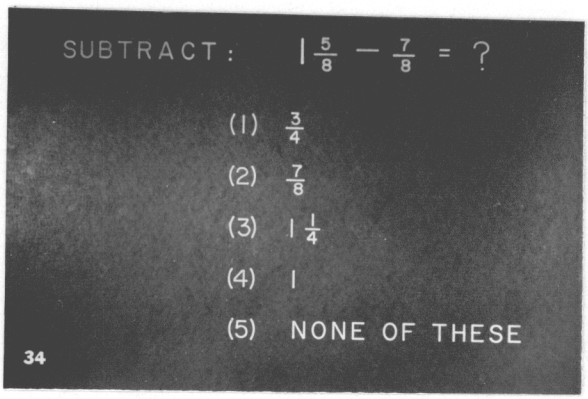
(2) Correct response

(3) Wrong operation used (Changed subtraction to addition.)

(4) Random response (Impulsivity)

(5) Lack of understanding of content (Does not know about integers.)

Frame Number 39



Script: Subtract: one and five-eighths minus seven-eighths equals?

Error Diagnosis:

(1) Correct response

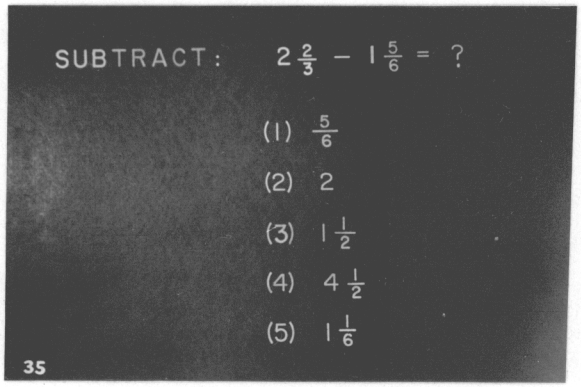
(2) Obvious computational error (Subtraction error.)

(3) Defective algorithm used (Subtracted smaller fraction from larger.)

(4) Defective algorithm used (Juxtaposed whole number and numerator in the mixed number.)

(5)

Frame Number 40



Script: Subtract: two and two-thirds minus one and five-sixths equals?

Error Diagnosis:

(1) Correct response

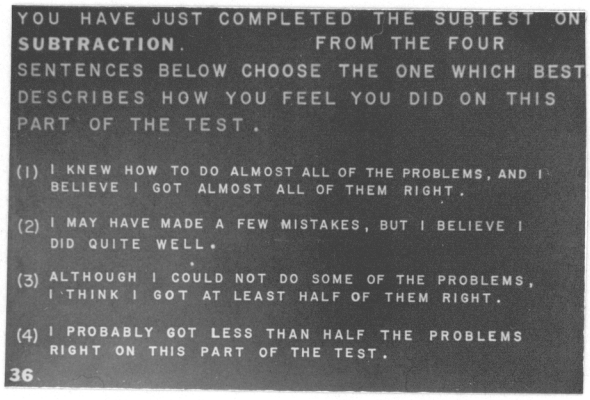
(2) Random response (Guessing)

(3) Defective algorithm used (Subtracted fractions wrong.)

(4) Wrong operation used (Added instead of subtracted.)

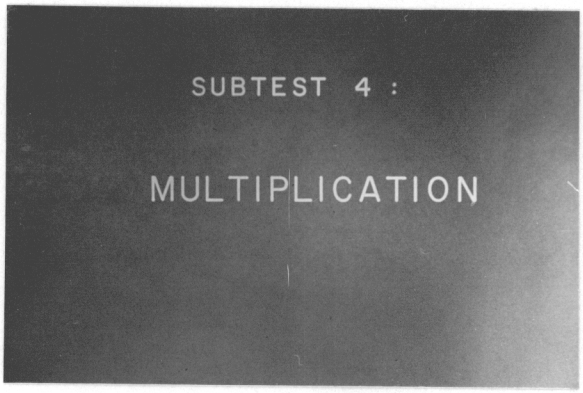
(5) Defective algorithm used (Subtracted smaller fraction from larger.)

Frame Number 41



Script: You have just completed the subtest on subtraction. From the four sentences below choose the one which best describes how you feel you did on this part of the test. The responses are the same as before. Read them and mark only one.

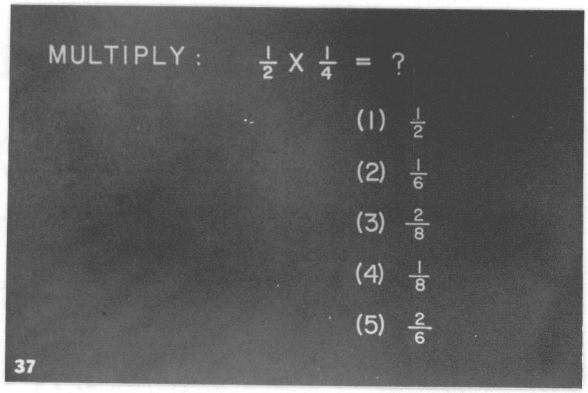
Frame Number 42



Script: Subtest number four: Multiplication.

Subtest 4 -- Multiplication

Frame Number 43



Script: Question 37. Multiply: one-half times one fourth equals?

Error Diagnosis:

(1) Defective algorithm used (Converted fractions to like denominators and used common denominator.)

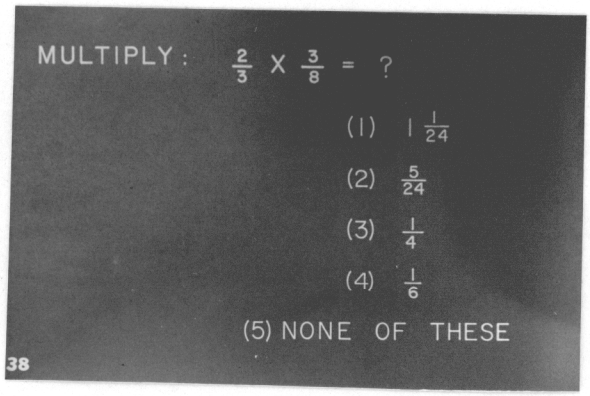
(2) Defective algorithm used (Multiplied numerators and added denominators.)

(3) Defective algorithm used (Added numerators and multiplied denominators.)

(4) Correct response

(5) Defective algorithm used (Added numerators and denominators.)

Frame Number 44



Script: Multiply: two-thirds times three-eighths equals?

Error Diagnosis:

(1) Defective algorithm used (Added numerators and multiplied denominators.)

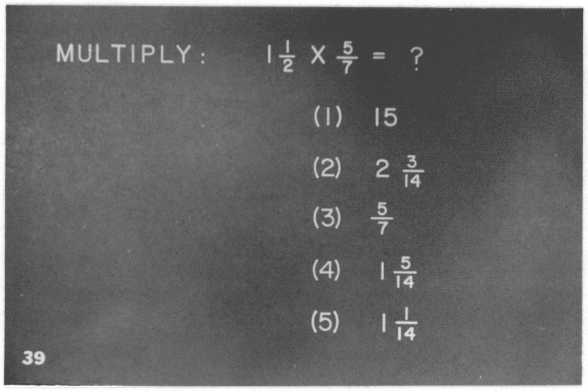
(2) Defective algorithm used (Added numerators and multiplied denominators.)

(3) Correct response

(4) Obvious computational error (Factored wrong after multiplying.)

(5)

Frame Number 45



Script: Multiply: one and one-half times five-sevenths equals?

Error Diagnosis:

(1) Defective algorithm used (Took cross product and subtracted numerators.)

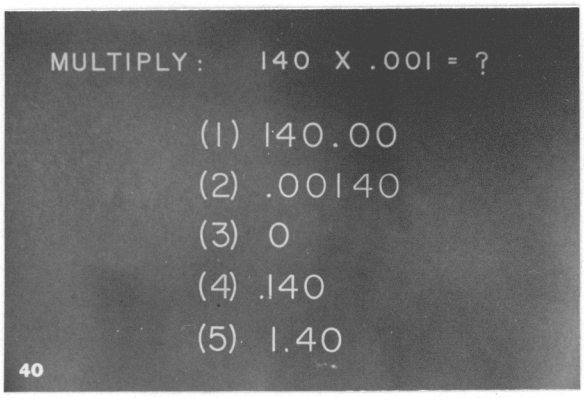
(2) Defective algorithm used (Took cross produce and added numerators.)

(3) Random response (Impulsivity)

(4) Defective algorithm used (Multiplied proper fractions together and added whole number.)

(5) Correct response

Frame Number 46



Script: Multiply: one hundred forty times one thousandth equals?

Error Diagnosis:

(1) Defective algorithm used (Added zeros and did not move decimal.)

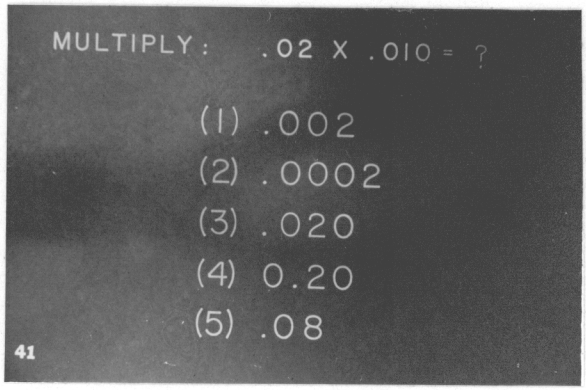
(2) Lack of understanding of content (Cannot locate decimal in product.)

(3) Random response (Guessing)

(4) Correct response

(5) Lack of understanding of content (Cannot locate decimal in product.)

Frame Number 47



Script: Multiply: two hundredths times ten thousandths equals?

Error Diagnosis:

(1) Lack of understanding of content (Cannot locate decimal in product.)

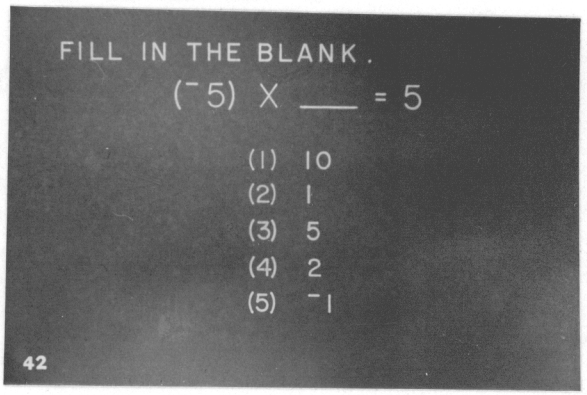
(2) Correct response

(3) Lack of understanding of content (Cannot locate decimal in product.)

(4) Lack of understanding of content (Cannot locate decimal in product.)

(5) Random response (Guessing or tried to subtract.)

Frame Number 48



Script: Fill in the blank. Minus five times blank equals five.

Error Diagnosis:

(1) Wrong operation used (Added instead of multiplying.)

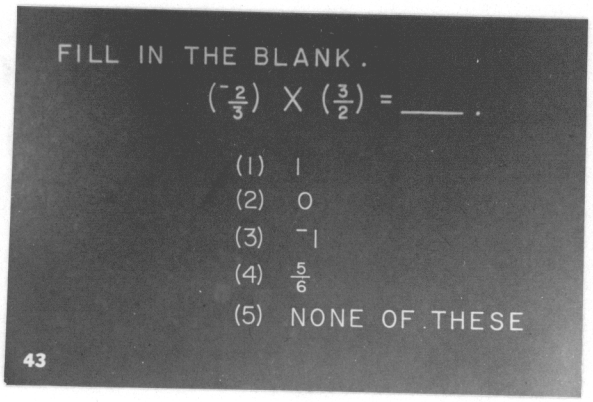
(2) Lack of understanding of content (Does not know sign rules for multiplication of integers.)

(3) Random response (Impulsivity)

(4) Random response (Guessing)

(5) Correct response

Frame Number 49



Script: Fill in the blank. Minus two-thirds times three-halves equals blank.

Error Diagnosis:

(1) Lack of understanding of content (Does not know rules of multiplication of rational numbers.)

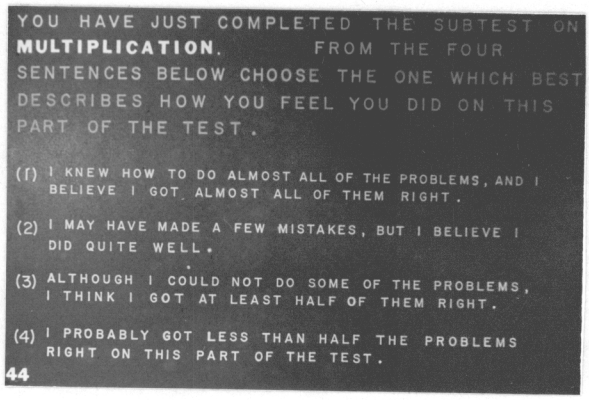
(2) Lack of understanding of content (Does not know multiplicative identity from additive identity.)

(3) Correct response

(4) Defective algorithm used (Added numerators, disregarding sign, and multiplied numerators.)

(5)

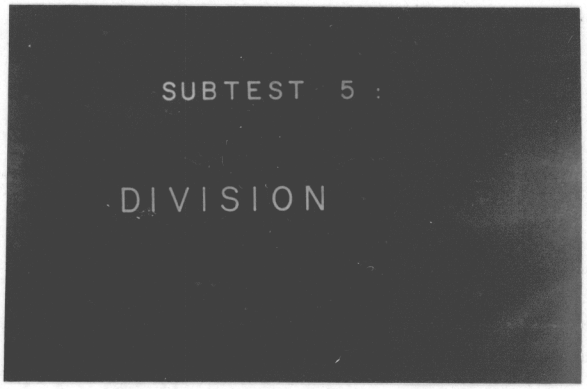
Frame Number 50



Script: You have just completed the subtest on multiplication. From the four sentences below choose the one which best describes how you feel you did on this part of the test. (Pause)

We will pause a moment so that the tape can be turned over. You will be on question forty-five when the test continues.

Frame Number 51



Script: Subtest number five: Division

Subtest 5 -- Division

Frame Number 52

Script: Question forty-five. Divide sixty-five into six thousand six hundred thirty.

Error Diagnosis:

(1) Obvious computational error (Error in subtraction.)

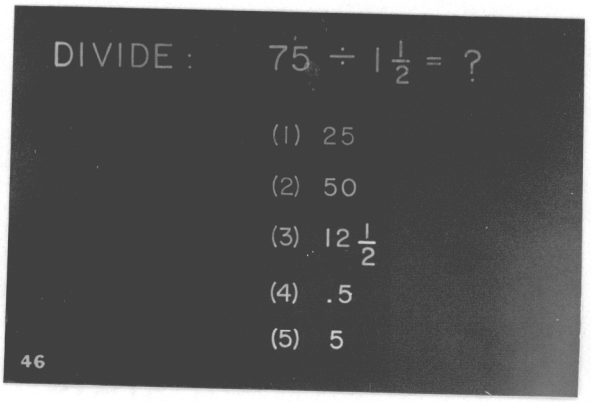
(2) Obvious computational error (Multiplication error.)

(3) Lack of understanding of content (Inappropriate use of zero as a placeholder.)

(4) Lack of understanding of content (Inappropriate use of zero as placeholder.)

(5) Correct response

Frame Number 53



Script: Divide: seventy-five divided by one and one-half equals?

Error Diagnosis:

(1) Obvious computational error (Forgot to multiply by 2 after converting mixed number.)

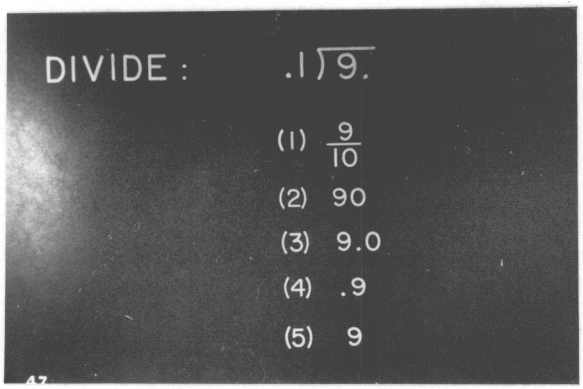
(2) Correct response

(3) Defective algorithm used (Problem in taking reciprocal.)

(4) Defective algorithm used (Changed to decimal and moved decimals incorrectly.)

(5) Defective algorithm used (Changed to decimals and moved decimals incorrectly.)

Frame Number 54



Script: Divide one-tenth into nine.

Error Diagnosis:

(1) Random response (Impulsivity)

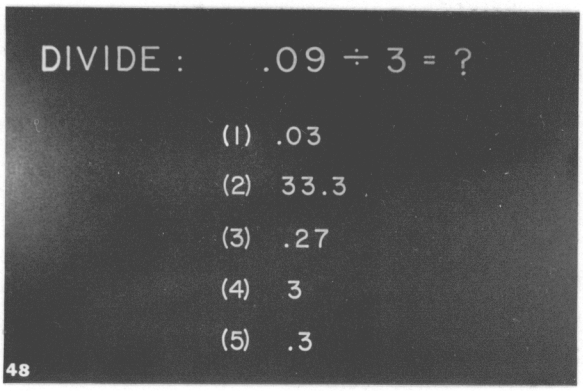
(2) Correct response

(3) Defective algorithm used (Did not move decimal in dividend.)

(4) Defective algorithm used (Moved decimal wrong way in dividend.)

(5) Defective algorithm used (Did not move decimal in dividend.)

Frame Number 55



Script: Divide: nine hundredths divided by three equals?

Error Diagnosis:

(1) Correct response

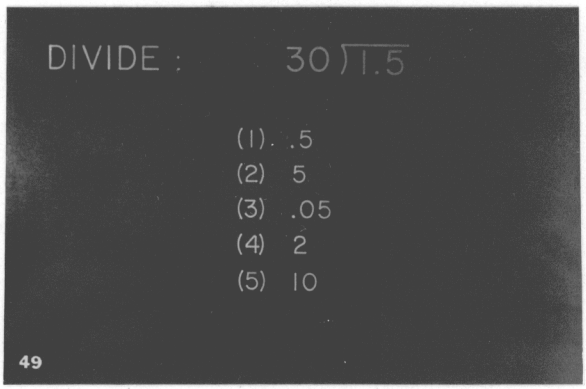
(2) Defective algorithm used (Confused dividend and divisor.)

(3) Wrong operation used (Multiplied instead of divided.)

(4) Lack of understanding of content (Ignored decimal and does not know role of zero as placeholder.)

(5) Lack of understanding of content (Does not know role of zero as a placeholder.)

Frame Number 56



Script: Divide thirty into one and five tenths.

Error Diagnosis:

(1) Lack of understanding of content (Ignored zero as a placeholder.)

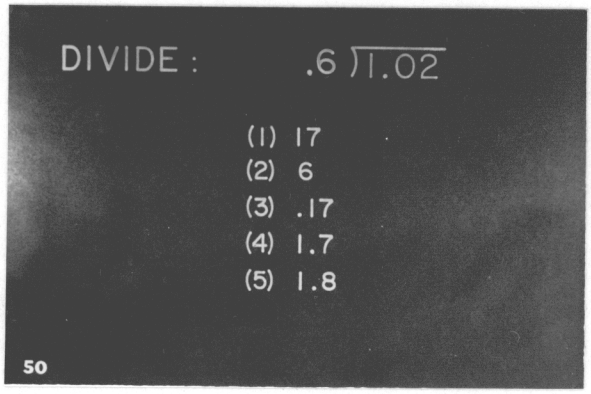
(2) Defective algorithm used (Moved decimal in dividend.)

(3) Correct response

(4) Wrong operation used (Multiplied instead of divided.)

(5) Random response (Guessing)

Frame Number 57



Script: Divide six tenths into one and two hundredths.

Error Diagnosis:

(1) Defective algorithm used (Moved decimal incorrectly in dividend.)

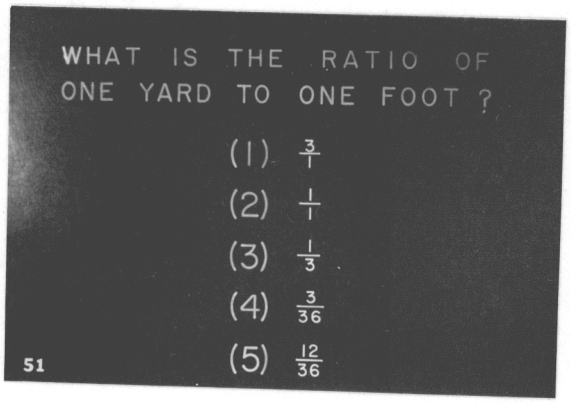
(2) Random response (Guessing)

(3) Defective algorithm used (Did not move decimal in dividend.)

(4) Correct response

(5) Obvious computational error (Subtracted wrong.)

Frame Number 58



Script: What is the ratio of one yard to one foot?

Error Diagnosis:

(1) Correct response

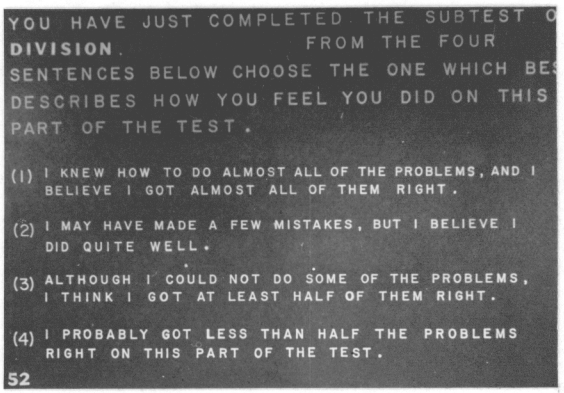
(2) Lack of understanding of content (Does not know types of measures.)

(3) Lack of understanding of content (Reversed the ratio.)

(4) Lack of understanding of content (Confusing measures.)

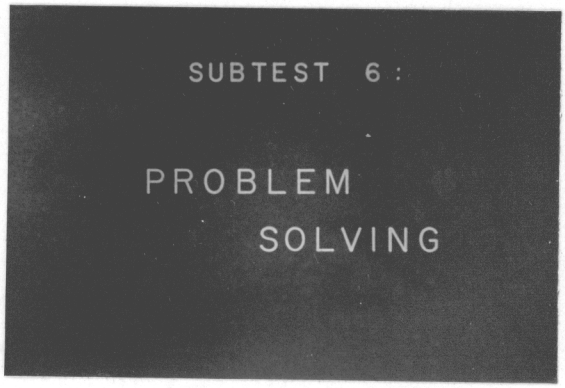
(5) Lack of understanding of content (Confusing measures.)

Frame Number 59



Script: You have just completed the subtest on division. From the four sentences below choose the one which best describes how you feel you did on this part of the test.

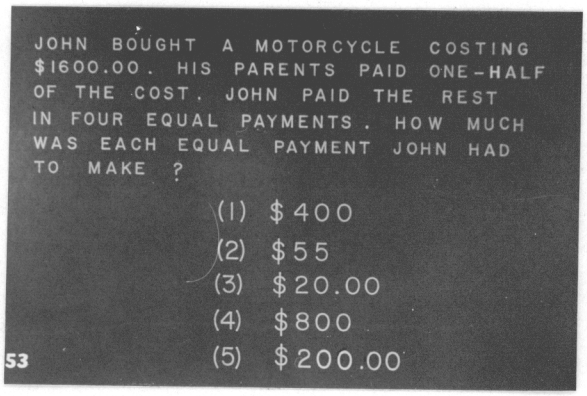
Frame Number 60



Script: Subtest number six: Problem Solving

Subtest 6 -- Problem Solving

Frame Number 61



Script: Question number fifty-three. John bought a motorcycle costing one thousand six hundred dollars. His parents paid one half of the cost. John paid the rest in four equal payments. How much was each equal payment John had to make?

Error Diagnosis:

(1) Reading

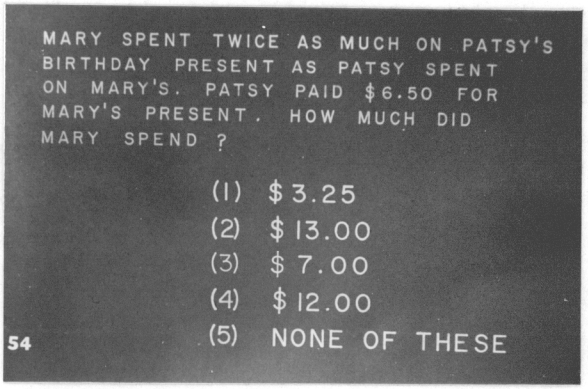
(2) Random response (Guessing)

(3) Obvious computational error (Decimal in wrong place.)

(4) Reading

(5) Correct response

Frame Number 62



Script: Mary spent twice as much on Patsy's birthday present as Patsy spent on Mary's. Patsy paid six dollars and fifth cents for Mary's present. How much did Mary spend?

Error Diagnosis:

(1) Wrong operation used (Divided instead of multiplied.)

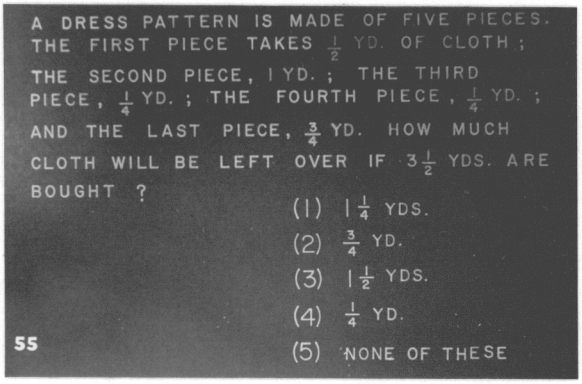
(2) Correct response

(3) Random response (Guessing)

(4) Obvious computational error (Faulty doubling.)

(5)

Frame Number 63



Script: A dress pattern is made of five pieces. The first piece takes one-half yard of cloth. The second piece, one yard. The third piece one-fourth yard. The fourth piece, one-fourth yard and the last piece three-fourths yards. How much cloth will be left over if three and one-half yards are bought?

Error Diagnosis:

(1) Obvious computational error (Subtraction error.)

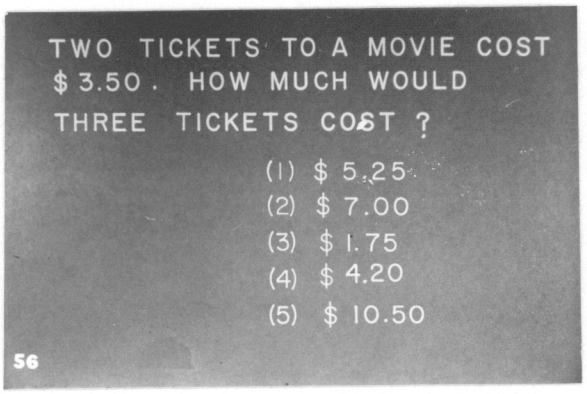
(2) Correct response

(3) Obvious computational error (Addition error.)

(4) Obvious computational error (Subtraction error.)

(5)

Frame Number 64



Script: Two tickets to a movie cost three dollars and fifty cents. How much would three tickets cost?

Error Diagnosis:

(1) Correct response

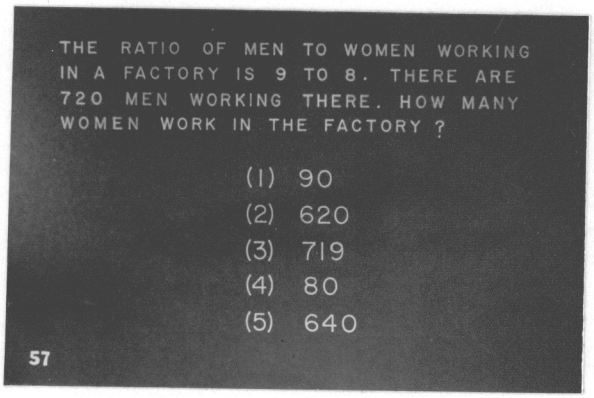
(2) Reading

(3) Random response (Impulsivity)

(4) Random response (Guessing)

(5) Reading

Frame Number 65



Script: The ratio of men to women working in a factory is nine to eight. There are seven hundred twenty men working there. How many women work in the factory?

Error Diagnosis:

(1) Defective algorithm used (Divided wrong number into 720.)

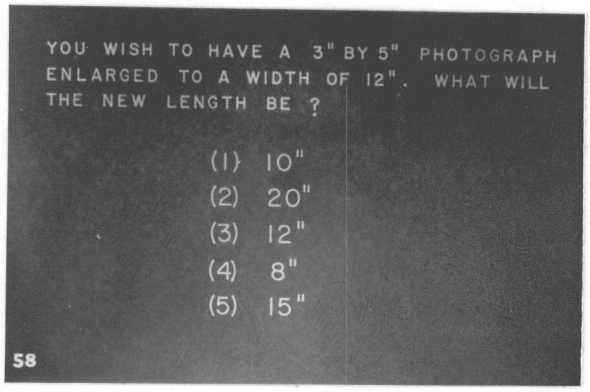
(2) Random response (Guessing)

(3) Wrong operation used (Subtracted instead of divided.)

(4) Defective algorithm used (Forgot to mulitply by 9.)

(5) Correct response

Frame Number 66



Script: You wish to have a three inch by five inch photograph enlarged to a width of twelve inches. What will the new length be?

Error Diagnosis:

(1) Random response (Guessing)

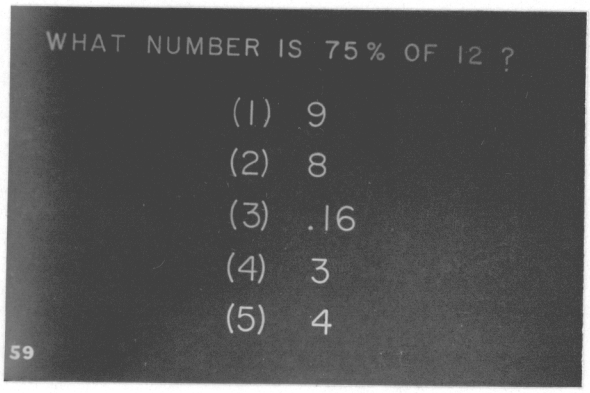
(2) Correct response

(3) Random response (Impulsivity)

(4) Lack of understanding of content (Confused width and length.)

(5) Random response (Guessing)

Frame Number 67



Script: What number is seventy-five percent of twelve?

Error Diagnosis:

(1) Correct response

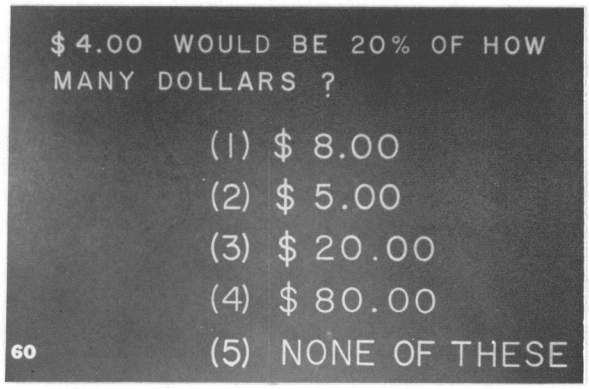
(2) Lack of understanding of content (Changed 75% to incorrect fraction.)

(3) Wrong operation used (Divided instead of multiplying.)

(4) Obvious computational error (Forgot the 3 in the numerator.)

(5) Defective algorithm used (Divided instead of multiplying and forgot numerator.)

Frame Number 68



Script: Four dollars would be twenty percent of how many dollars?

Error Diagnosis:

(1) Wrong operation used (Multiplied instead of dividing.)

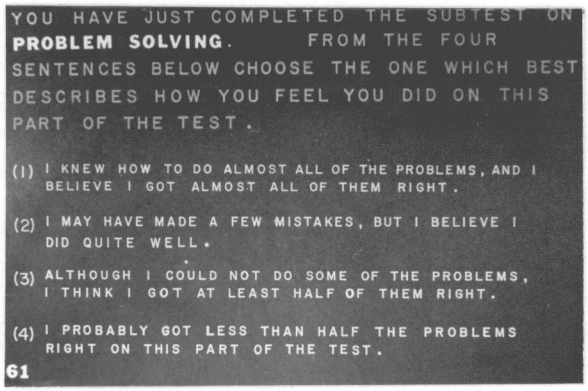
(2) Defective algorithm used (Divided base into percent.)

(3) Correct response

(4) Wrong operation used (Multiplied instead of dividing and ignored percent sign.)

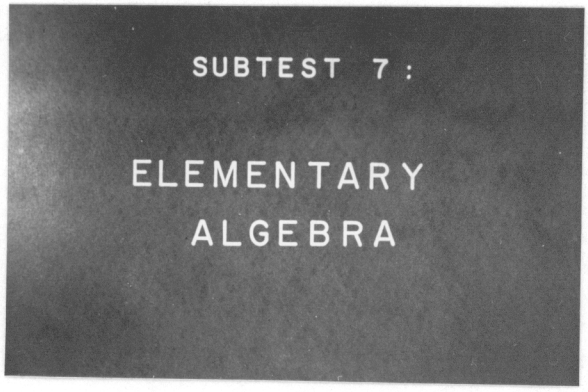
(5)

Frame Number 69



Script: You have just completed the subtest on problem solving. From the four sentences below choose the one which best describes how you feel you did on this part of the test.

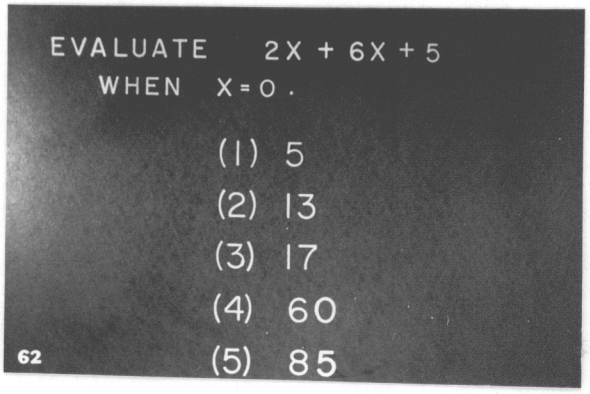
Frame Number 70



Script: Subtest seven: Elementary Algebra.

Subtest 7 -- Elementary Algebra

Frame Number 71



Script: Question number sixty-two. Evaluate two X plus six X plus five when X equals zero.

Error Diagnosis:

(1) Correct response

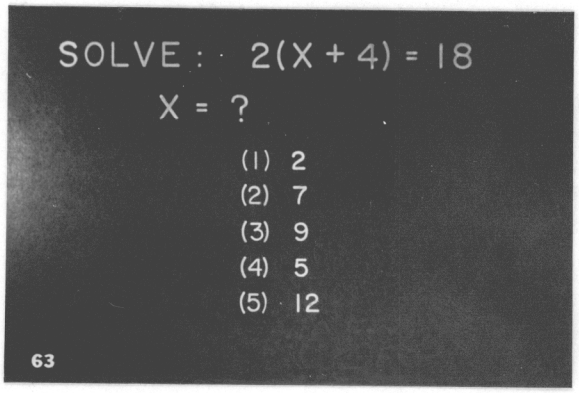
(2) Lack of understanding of content (Does not know role of X in algebra.)

(3) Lack of understanding of content (Thinks X means multiplication.)

(4) Lack of understanding of content (Thinks X means multiplication.)

(5) Lack of understanding of content (Does not know how to read algebraic symbolism.)

Frame Number 72



Script: Solve two parenthesis X plus four parenthesis equals eighteen. X equals ?

Error Diagnosis:

(1) Random response (Guessing)

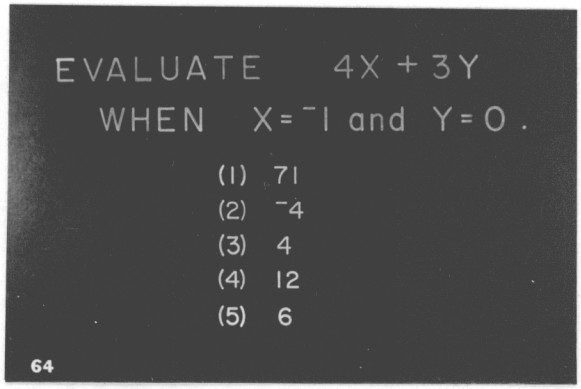
(2) Lack of understanding of content (Cannot use the distributive law of multiplication over addition.)

(3) Random response (Impulsivity)

(4) Correct response

(5) Lack of understanding of content (Does not know algebraic symbolism.)

Frame Number 73



Script: Evaluate four X plus three Y when X equals negative one and Y equals zero.

Error Diagnosis:

(1) Lack of understanding of content (Does not know algebraic symbolism.)

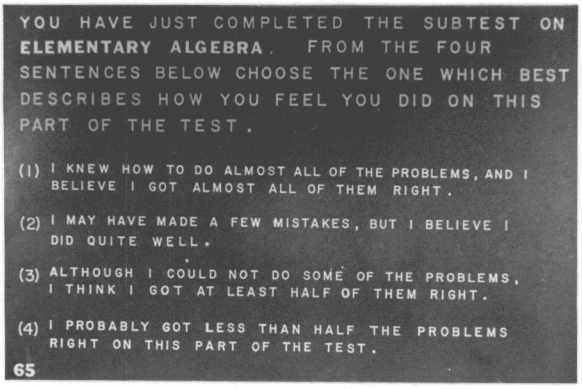
(2) Correct response

(3) Ignored necessary symbol, not operation (Minus sign.)

(4) Lack of understanding of content (Does not know algebraic symbolism.)

(5) Lack of understanding of content (Does not know algebraic symbolism.)

Frame Number 74



Script: You have just completed the subtest on elementary algebra. From the four sentences below choose the one which best describes how you feel you did on this part of the test.

Frame Number 75

Script: This is the end of the Basic Mathematics Diagnostic Instrument. Please wait for your instructor to give you directions on how he or she wishes to collect the pencils, scratch paper, and answer sheets.

APPENDIX D

A. Letter to Developmental Instructors Participating in Field Study.
B. Teacher Questionnaire

COLLEGE OF EDUCATION

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

Blacksburg, Virginia 24061

OFFICE OF RESEARCH & EVALUATION SERVICES

Dear Developmental Mathematics Instructor:

In the first days of classes this fall, your developmental students in arithmetic and beginning algebra were given the Basic Mathematics Diagnostic Instrument. Since this was a field test of this instrument, I need to have some feedback concerning the usefullness of this test in your teaching.

You received profile sheets giving you profiles of each student's strenths and weaknesses in arithmetic and beginning algebra, a profile of propensity for specific types of errors, and a perception of performance survey. Please complete the enclosed questionnaire and return it to me no later than October 15, 1975.

I greatly appreciate the cooperation you gave me in the administration of this test and I wish for you much success in the difficult task of teaching developmental mathematics.

Sincerely yours,

Deanna G. Bowman

Deanna G. Bowman

BASIC MATHEMATICS DIAGNOSTIC INSTRUMENT

TEACHER QUESTIONNAIRE

Please rate A through E according to the choices given. Place an X in the blank to the left of the response you deem most appropriate.

A. STRENGTHS AND WEAKNESSES PROFILE SHEETS

PURPOSE: To give a graphical representation of a student's strengths and weaknesses and to assist the instructor in ascertaining a student's initial competencies in arithmetic and beginning algebra.

I found the profile sheets to be
_____(1) of little or no assistance
_____(2) of some assistance
_____(3) of substantial assistance
_____(4) of very great assistance.

B. SLIDE-TAPE PRESENTATION

PURPOSE: To assist the developmental student with reading problems by presenting the test in both aural and visual modes.

For the benefit of most developmental mathematics students, I found the dual mode presentation to be
_____(1) of little or no benefit
_____(2) of some benefit
_____(3) of substantial benefit
_____(4) of very great benefit.

C. PROPENSITY FOR ERRORS PROFILE SHEET

PURPOSE: To give the instructor an insight into the types of errors the student most frequently makes in computation and problem solving.

I found the propensity for errors profile to be
_____(1) of little or no help
_____(2) of some help
_____(3) of substantial help
_____(4) of very great help.

D. PERCEPTION OF PERFORMANCE SURVEY

PURPOSE: To obtain the student's judgement of his performance on the test as an aid to counseling him in developmental mathematics.

I believe the perception of performance survey gave me information
_____(1) of little or no use
_____(2) of some use
_____(3) of substantial use
_____(4) of very great use.

E. Considering the information I have available on each developmental mathematics student and in comparison to other tests available for my use, I believe the Basic Mathematics Diagnostic Instrument gave to me
_____(1) less useful information concerning mathematical abilities and student attitudes
_____(2) about the same information concerning mathematical abilities and student attitudes
_____(3) more useful information concerning mathematical abilities and student attitudes
_____(4) a great deal more information concerning mathematical abilities and student attitudes.

Please use the reverse side of this sheet to make comments or present suggestions.

VITA

Deanna Gay Bowman was born in Roanoke, Virginia, May 28, 1941. She was graduated from Hillsville High School, Hillsville, Virginia in 1958. She received the Bachelor of Science in Education degree from Madison College, Harrisonburg, Virginia in 1962. In September, 1962, she began teaching mathematics at a junior high school in Roanoke, Virginia. In the summer of 1963, she attended the University of Arizona, Tucson, Arizona. From 1963 to 1965, she taught mathematics in Carroll County Virginia schools. In the summers of 1964 and 1965 she returned to Madison College for further study in mathematics. She was a graduate teaching assistant in the Department of Mathematics, Virginia Polytechnic Institute 1966-1967. She received the Master of Science degree in Mathematics from Virginia Polytechnic Institute, Blacksburg, Virginia, in 1967. She was instructor of mathematics at Appalachian State University, Boone, North Carolina, for three years. In 1970, she became instructor/advisor in mathematics to the Special Services Project, Wytheville Community College, Wytheville, Virginia.

In June, 1973, she began study leading toward the Doctorate in Education at Virginia Polytechnic Institute and State University. While pursuing her doctorate she was a graduate teaching assistant supervising student teachers in mathematics. She also received a graduate research assistantship for summer, 1974.

She is a member of the remedial mathematics committee of the Mathematics Association of Two-Year College Educators, The Mathematical Association of America, Phi Delta Kappa, and Phi Kappa Phi.

Deanna Kay Bowman

A BASIC MATHEMATICS DIAGNOSTIC INSTRUMENT

by

Deanna Gay Bowman

(ABSTRACT)

A diagnostic test in basic mathematics was developed to determine a student's strengths and weaknesses in numeration, arithmetic operations, problem solving and elementary algebra. The test was designed for use in community colleges with individualized developmental programs for underprepared students in mathematics. The Basic Mathematics Diagnostic Instrument is a group-administered test; however, an examinee's responses yield diagnoses of his content area strengths and weaknesses, propensities for specific types of errors and personal perceptions of performance adequacy in each content area. The diagnostic information is produced in the form of graphic profiles to facilitate the instructor's interpretation of a student's performance.

The development of the Basic Mathematics Diagnostic Instrument took into consideration the characteristics of the underprepared students in basic mathematics in community colleges. To aid students with reading problems, the test is a slide-tape presentation produced in redundant aural and visual modes. To encourage recall of previously learned skills, the test is in multiple-choice format.

The estimated reliabilities of the content area and error-type scores are included based on a sample of 435 students from four

community colleges serving diverse student populations. A survey of instructors who participated in the field study yields information concerning the value of the Basic Mathematics Diagnostic Instrument in determining appropriate programs of remediation for each student.