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A COMPARATIVE ANALYSIS OF THE STRUCTURE OF TWO VERSIONS OF THE GRADE TEN MICHIGAN EDUCATIONAL ASSESSMENT PROGRAM MATHEMATICS TEST

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A COMPARATIVE ANALYSIS OF
THE STRUCTURE OF TWO VERSIONS OF THE GRADE TEN
MICHIGAN EDUCATIONAL ASSESSMENT PROGRAM
MATHEMATICS TEST

By

JoAnne Ellen Moore

A DISSERTATION

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CHAPTER I

Background of the Study

Introduction

The Department of Education of the State of Michigan, under the leadership of John Porter, State Superintendent of Public Instruction, instituted a state-wide assessment program in 1969. This program was proposed to act as a barometer of the state of basic skills instruction in Michigan at several key grade levels. The Michigan Educational Assessment Program (MEAP) began as a norm-referenced instrument administered in the fourth and seventh grades. The test was designed to assess, on a state-wide basis, student performance in word relationships, reading, mechanics of written English, and mathematics.

In 1973, the assessment instrument was changed from a norm-referenced to an objective-referenced instrument. According to Huyser,

> The Department of Education has attempted to develop assessment tests which accurately reflect educational attainment of the state's fourth and seventh grade students. These tests were developed with the involvement of Michigan teachers and subject matter specialists. The tests and

> processing methods reflect the highest level of quality permitted by the present state of the art in objective-referenced testing.[1]

These new assessment instruments were administered to students during the fall of the school year and the objectives tested and items used remained fairly constant[2] from 1973 through fall, 1979. Of the 455 mathematics objectives written, 33 were assessed at the fourth grade level and 45 were assessed at the seventh grade level. Each objective was measured using five test items. Attainment of the objective required that at least four out of five of these items be answered correctly.

Plans for a Grade 10 assessment test were made at the time that the objective-referenced instruments were introduced. The Grade 10 instrument was piloted in 1977 and 1978 in several districts throughout the state. It was first administered on a state-wide basis in the fall of 1979. The number of objectives assessed in Grade 10 mathematics was 40. The success criterion for mathematics was three out of four correct.

In 1975, a revision of the assessment tests was begun. Over a five year period, the basic reading and mathematics assessment instruments were significantly revised at all three levels. A significant influence upon these revisions was exerted by Veitch, Bauer, and Slawski.[3] Working with data from the Grade 4 Michigan

Educational Assessment Program (MEAP) reading test, they indicated that the Rasch model could be used to produce a ten-item test which would classify students on a Rasch ability scale as accurately as the 95-item MEAP with minimal error.

Two professional associations worked on the revisions: the Michigan Reading Association and the Michigan Council of Teachers of Mathematics. The revisions focused upon reducing testing time and providing more useful data to Michigan educators and local school districts as well as to the state.

Experimental versions of the new MEAP tests were completed in 1979. The revisions which were undertaken involved several steps. First, the minimal objectives numbered 624. Second, the number of test items used to assess mastery of each objective was reduced to three in all areas and at all levels. Third, the criterion for success on the revised edition became two correct out of three.

The revised version of the Grade 10 MEAP mathematics test was changed from a single form to four forms. Each of these four forms tested 28 core objectives along with seven correlates, a total of 35 objectives assessed on each form of the test. This compared with 40 objectives which were tested on the old form. This reduction in the number of objectives assessed together with testing only three items for each objective resulted in a test which required less testing time. More objectives were assessed on a state-wide sampling basis (56 in all) due to the fact that four forms were used. Every pupil data was available on only the 28 core objectives and these 28 were to be the basis for reporting school district level data and for annual comparisons of student performance state-wide.

The revised instruments were administered on a trial basis in 1979 to a sample of 72 volunteer schools representing the six demographic strata of the state: Southeast Metro, Outstate Metro, Outstate Rural, Southeast Suburb, Outstate Suburb, and Northern. Each participating school gave the old version of the test to its pupils along with an experimental test (either reading or mathematics) which contained five items per objective. Data from this administration of the test provided the item statistics used to select the three items which would appear on the final version of the new test. Three considerations were used to select the three items:

(1) the three items should adequately cover the domain of the objective;
(2) the three items should have similar percents of students responding correctly; and
(3) the subset of three items should have a relatively high KR-20 value.[4]

This item selection process was undertaken in an effort to make the old and new versions of the MEAP tests comparable based upon proportions data. Data from the

MEAP tests were reported in a Proportions Report format which specified the percent of pupils achieving various objectives in reading and mathematics. The percent breakdown of objectives achieved was in four categories: Category #1, 0-25% achieved; Category #2, 26-50% achieved; Category #3, 51-75% achieved; and Category #4, 76-100% achieved.

> The proportions data for the students in the equating study sample [for the items selected based upon the criteria above] were compared to the proportions data from the same students for the base [old] test, using five items per objective. At each grade level adjustments were made in the objectives and items until the proportions data for the selected objectives and items were comparable with the proportions data for the base [old] test. Adjustments in the selection of objectives were made in a way to maintain the balanced coverage of skill areas. Adjustments in the selection of items were made in a way to maintain the criteria used in item selection.[5]

Each of the objectives tested on the Grade 10 MEAP mathematics tests is classified in a skill area. The old version of the Grade 10 MEAP mathematics test assessed objectives in ten skill areas: whole number division; fractions; decimals; integers; ratio, proportion, percent; geometric measurement; non-geometric measurement; geometry; algebra; and probability and statistics. The new version of the Grade 10 MEAP mathematics test assessed objectives in nine skill areas: whole numbers; decimals; fractions; ratio, proportion, percent; metric measurement; non-metric measurement; geometry; probability and statistics; and equations, expressions, graphs. Data on students' average percent attainment of objectives grouped by skill area and percent of students attaining mastery of each of the objectives on the test are reported on the Proportions Report along with percent of students in each of the four achievement categories. The equating process for the old and new versions of the MEAP test was based on the proportions data (percent of students in each of the four categories) since, if similar percentages of students were in each of the four categories of achievement when the two tests were administered within a brief interval, the results could continue to be used to identify schools' status and progress with respect to allocation of state compensatory education funds since this allocation and status determination was based upon proportions data.[6]

The new MEAP tests which resulted from the item selection process described above were administered on a state-wide basis for the first time in the fall of 1980. As during the 1979 administration, several districts also administered either the reading or mathematics section of the old version of the test in addition to the new version of the test in order to obtain data on both instruments based on the same set of students.

Statement of the Problem

The purpose of this study was to examine the structure of both the old and the new versions of the Grade 10 MEAP mathematics test in an effort to determine the underlying factor structure of the instruments. That is, to what extent could the objectives be said to relate to the respective categories to which they had been assigned on each test and to what extent did the old and new versions of the test have the same structure.

This investigation was limited to the Grade 10 MEAP mathematics tests for several reasons. First, the mathematics tests had not previously been subjected to factor analysis. Second, high school mathematics was the investigator's area of expertise. Third, the Grade 10 tests were the newest instruments and, therefore, were in the greatest need of research findings which would enhance the usefulness of the instruments.

Significance of the Problem

This study was significant due to the fact that it investigated the structure of two versions of the Grade 10 MEAP mathematics test from a new perspective. Other investigations of these instruments, which were undertaken in an effort to equate them, concentrated upon the classification of students based upon their scores on the two versions of the test. The examination of the factor structure of the two instruments and attempts to equate the factors found in the two versions was a different approach to the problem of test equating for the MEAP. In addition, the model developed for this investigation is applicable to comparisons among other objective-referenced tests which attempt to measure the same domain. Traditional methods of test equating based upon correlation coefficients are not suitable for objective-referenced tests where the variance in student scores is limited. This model may serve as a suitable alternative to the more traditional approaches.

Educational Implications

Proportions data from the MEAP tests are used by the Michigan Department of Education to allocate state compensatory education monies to local school districts. These allocations are based upon three consecutive years of MEAP data for each school district. When the MEAP tests were revised and the new versions implemented in the fall of 1980, two different versions of the test were used in implementing these longitudinal comparisons. The comparability of the MEAP test results was essential if these comparisons were to be justified. In addition, the results of the MEAP tests are used by local school districts, local schools, and on a state-wide basis to determine the level of basic skills achievement in reading and mathematics. If the new versions give significantly different information with respect to achievement levels, these comparisons are not valid. Since a stated purpose of the MEAP program was this assessment, the comparability of the two versions of the test is of great educational significance.

Definition of Terms

This study investigated two versions of the Michigan Educational Assessment Program (MEAP) mathematics test for students in Grade 10. The Michigan Educational Assessment Program

> was created to provide information on the status and progress of Michigan's basic skills education. The results show whether or not students are learning identified basic skills in reading and mathematics and whether or not more students are acquiring this information each year. Using this information, government officials and educators at all levels can make better fiscal and programmatic decisions.[7]

MEAP tests are administered in grades four, seven, and ten in the fall of each year. This study focused on the Grade 10 mathematics portion of the test.

The old version of the test refers to the Grade 10 MEAP mathematics test which was administered from 1973 through 1979 on a state-wide basis. The new version of the test refers to the Grade 10 MEAP mathematics test which was first administered in the fall of 1980 on a state-wide basis. The new version has four forms containing 28 core objectives (appearing on all four forms) and 7 correlates which differ on each of the four forms of the test. Since the sample of students participating in this study took various forms of the test, and since only the 28 core objectives are used by the Michigan Department of Education to make longitudinal comparisons, this study considered the new version of the test to consist of only these 28 core objectives.

MEAP data are reported in a proportions report. This report indicates the percent of pupils achieving various objectives in mathematics and reading. The percent breakdown of objectives achieved is in four categories: Category #1, 0-25% achieved; Category #2, 26-50% achieved; Category #3, 51-75% achieved; and Category #4, 76-100% achieved. The proportions report also indicates the skill area classification of each of the objectives tested on the MEAP tests. The old version of the Grade 10 MEAP test assessed objectives in ten skill areas while the new version of the Grade 10 MEAP mathematics test assessed objectives in nine skill areas. Specific information on which objectives were assigned to each skill area may be found in Appendix A.

Kerlinger defines factor analysis as

> a method of determining the number and nature of the underlying variables among larger numbers of measures. More succinctly, it is a method of determining k underlying variables (factors) from n sets of measures, k being less than n. It may also be called a method for extracting common factor variances from sets of measures.[8]

Factor analysis involves three steps in order to be implemented: (1) a correlation matrix must be prepared which shows the relationship of all variables to each other; (2) initial factors must be extracted; and (3) these initial factors must be rotated to an interpretable solution. This study used student scores on objectives as the variables for step (1), iterated principal components analysis where estimates of communalities were entered in the diagonal of the correlation matrix in step (2), and Kaiser's varimax criterion for rotation in step (3).

The decision as to the number of factors to be rotated was based upon the eigenvalues of the initial factors. An eigenvalue represents the proportion of total variance accounted for by the factor in principal components analysis if it is divided by the number of variables being factored. By retaining only factors with eigenvalues greater than one, as was done in this study, it is assured that components which account for at least the amount of the total variance of a single variable will be treated as significant.

Factor scores are defined by Kim and Mueller as "the estimate for a case on an underlying factor formed from a linear combination of observed variables."[9] In this study, factor scores were computed using the factor loadings of each variable on each factor together with each individual's score on that variable in order to compute a score for each individual on each of the factors.

Questions to be Answered

This study asked the following questions:

1. What is the correlation between the number of items correct and the number of objectives achieved on the old version of the Grade 10 MEAP mathematics test?

2. What is the correlation between the number of items correct and the number of objectives achieved on the new version of the Grade 10 MEAP mathematics test?

3. What is the correlation between the total score (number correct) on each of the two versions of the Grade 10 MEAP mathematics test?

4. What is the correlation between the number of objectives achieved on each of the two versions of the Grade 10 MEAP mathematics test?

5. What is the underlying factor structure of the old version of the Grade 10 MEAP mathematics test?

6. To what extent does the factor structure of the old version of the Grade 10 MEAP mathematics test match the ten skill areas to which the objectives are assigned by the MEAP staff on the proportions report?

7. What is the underlying factor structure of the new version of the grade 10 MEAP mathematics test?

8. To what extent does the factor structure of the new version of the Grade 10 MEAP mathematics test match the nine skill areas to which the objectives are assigned by the MEAP staff on the proportions report?

9. Can the two versions of the Grade 10 MEAP mathematics test be said to be equivalent based upon correlations among factor scores derived from the factor analyses of the two versions of the test?

10. Are decisions based upon the results of the old and new versions of the Grade 10 MEAP mathematics test likely to be the same regardless of which form of the test is used?

Importance of the Problem

Answers to these questions will provide important information to the Michigan Educational Assessment Program staff at the Michigan Department of Education concerning the structure of the two versions of the Grade 10 MEAP mathematics test.

The model developed in this study will provide a basis for evaluating future revisions of the MEAP tests and for comparing versions of the MEAP test. The factor analytic approach will provide a method for checking the validity of the MEAP test in terms of the underlying constructs being assessed by the instrument which does not solely depend upon concensus of educators from across the state, but which can be replicated across various samples of students at various times.

The model developed in this study may be applied to any set of objective-referenced tests which are to be compared in terms of the traits they measure. It is especially important since the traditional methods for equating tests, which depend upon correlation coefficients, assume significant amounts of variance in test scores which may not be present in objective-referenced testing situations where students tend to score uniformly high. This restriction in variance may be of two types: a skewed distribution or a distribution which is restricted in range. The effect of ill behaved distributions on factor solutions was investigated by Olsson.[10] Using Monte Carlo methods, he found that ill behaved distributions tended to contribute to increased specific factor variance and decreased common factor variance. These changes, however, seem not to distort the solution in the common factor space. The studies were conducted on simple factor spaces and may not be applicable to the more complex factor structures investigated here. It must be acknowledged, in any case, that relatively little work has been done to detect the precise effects of ill behaved distributions on complex factor solutions. It is an area which clearly requires more extensive study and clarification.

In this study, the distributions of scores for the subjects were not badly skewed. The range of objective scores was limited by the numbers of items per objective. Within this limitation, considerable variance was present.

Notes

[1]Robert J. Huyser, Supervisor, Michigan Educational Assessment Program. Memorandum, March 11, 1974.

[2]Metric measurement objectives were substituted for some of the original mathematics objectives and some other minor changes were made after the first year.

[3]William R. Veitch, "An Application of the Rasch Model." Paper presented at the annual meeting of the Michigan School Testing Conference (Ann Arbor, Michigan, March, 1979).

Ernest A. Bauer, E. Slawski, and W. Veitch, "How Minimal is Minimal?" Paper presented at the annual meeting of the National Council on Measurement in Education (63rd, San Francisco, California, April 8-12, 1979).

Edward J. Slawski and Ernest A. Bauer, "Reducing Testing Time While Preserving Test Information: A Ten Item Fourth Grade MEAP Reading Test." Paper presented at the annual meeting of the Michigan Educational Research Association (Detroit, Michigan, March 17, 1978).

[4]Michigan State Board of Education, Technical Report, Volume I, Michigan Educational Assessment Program, Lansing, Michigan. 1980, p. 17.

[5]Ibid.

[6]Irene M. Leland, and others, "Using Achievement Tests to Fund a State-Wide Compensatory Education Program." Paper presented at the annual meeting of the American Educational Research Association (62nd, Toronto, Ontario, Canada, March 27-31, 1978).

[7]Michigan State Board of Education, Technical Report, Volume I, Michigan Educational Assessment Program, Lansing, Michigan. 1980, p. 1.

[8]Fred N. Kerlinger, Foundations of Behavioral Research, Second Edition. Holt, Rinehart, Winston, Inc., New York, 1964, p. 659.

[9] Jae-On Kim and Charles W. Mueller, Factor Analysis: Statistical Methods and Practical Issues. Quantitative Applications in the Social Sciences No. 14 (Beverly Hills, CA: Sage Publications, Inc., 1978). p. 84.

[10] U. Olsson, "On the Robustness of Factor Analysis Against Crude Classification of Observations." Multivariate Behavioral Research, 14:485-500, 1979.

CHAPTER II

Review of Related Literature

The literature review for this study was divided into two major sections: literature related to the Michigan Educational Assessment Program (MEAP) and literature related to factor analysis. This review examined these two areas separately.

Michigan Educational Assessment Program

A major source of published information on MEAP was the Michigan Department of Education (MDE). Additional articles and studies were written and completed by persons outside of the Department who were very much involved in Michigan education.

A large volume of reports was generated by the Michigan Department of Education for public dissemination and interpretation to respective audiences, such as local school districts, teachers, parents, students, and the State Legislature. These reports included methods and procedures, uses of objectives, interpretive manuals, and support materials designed to assist teachers in utilizing MEAP results in teaching. For the first several years of the program (prior to 1973), score reports made norm-referenced comparisons among school districts based upon the MEAP results.

When the MEAP test was changed to an objective-referenced instrument in 1973, norm-referenced comparisons were eliminated and local districts were encouraged to view the results as "....revolutionary to education in Michigan because they--for the first time--reflect[ed] student attainment of a specific set of learner performance objectives."[1] Students were examined in terms of which objectives they had achieved and which objectives they had not achieved. Local districts were to look at their results in light of their curricula before assuming that there was a deficiency either in student performance or in teaching strategies.

In addition to interpretive information and score reports, the Michigan Department of Education (MDE) published books of minimal objectives[2,3] in reading and mathematics, a subset of which are tested by the MEAP test. They also published support materials[4,5] for mathematics and reading which were designed for use by classroom teachers to remediate skills which were not mastered on the MEAP test.

The MEAP support materials were produced by the Michigan Council of Teachers of Mathematics (MCTM). The MCTM was very active in reviewing test items and otherwise lending assistance to MDE in its effort to assess mathematics achievement in Michigan. As a corollary to these activities, the MCTM published four monographs, in their series entitled, "Guidelines for Quality Mathematics Teaching," related to the MEAP.

The first monograph[6] was a discussion of the objectives assessed by the objective-referenced MEAP test. Sample lesson plans which included means for including MEAP objectives were presented. Limitations of the objectives were discussed.

The second MEAP related monograph[7] was an in-depth study of the norm-referenced MEAP mathematics tests administered from 1970-1973 to students in grades four and seven. This monograph traced the history of the program through 1973, assessed the quality of the instruments, and analyzed student achievement on each of the test items.

The third MEAP related monograph "[was] concerned with the 1973 (MEAP) results for the mathematics objectives on the Grade 4 and Grade 7 tests. Its major purpose [was] to make interpretive remarks about the performance levels of each objective tested and to make relevant teaching and curriculum suggestions."[8] Persons engaged in either staff development or interpretation of local MEAP results were the intended audience for this monograph.

The fourth MEAP related monograph[9] looked at the results in Grades 4 and 7 mathematics for 1974. It was directed toward classroom teachers and emphasized strategies which could be employed with students to improve minimal mathematics skills attainment levels. Sample diagnostic tests were included.

The MEAP was originally intended as one component of the Michigan Accountability System. House, Rivers, and Stufflebeam[10] criticized the MEAP on the following grounds: (1) the Common Goals upon which the objectives were based were broad, overlapping, and needed revision; (2) the objectives were not minimal and might lead to a state controlled curriculum; (3) the assessment was focused only on mathematics and reading, the objective-referenced tests were not validated, and the testing of every pupil in grades four and seven was not defensible; (4) the delivery system for the program should identify and analyze alternative programs, the current system tied money for compensatory education programs to assessment scores resulting in the paradox of keeping dollars by failing to raise scores; and (5) no effort was made to use the assessment data in making curricular decisions at the local school district level. In discussing the technical aspects of the MEAP objective-referenced tests, House, Rivers, and Stufflebeam noted,

> The objective-referenced tests [had] admirable reliability.... In other words, the five items used to measure each objective seem[ed] to be measuring the same thing in a consistent manner....

> Hence, we must conclude that the reliability of the tests [was] good but that their validity [was] questionable and require[d] further examination.[11]

They recommended slower test development, matrix sampling, voluntary testing, more emphasis on school-based evaluation, and an end to the practice of tying compensatory education monies to MEAP results.

In response to House, Rivers, and Stufflebeam, C. Phillip Kearney, David L. Donovan, and Thomas H. Fisher defended the assessment program.

> The whole issue reduce[d] itself to whether there [was] a common core of objectives that transcend[ed] local district boundaries and which all schools should help students attain. The Department's position [was] that these objectives [did], in fact, exist, that they [were] identifiable through a rational process, and that the effort [was] worthwhile.... [I]f no common core exist[ed], families moving from one location to another [were] in trouble.[12]

This MDE publication, A Staff Response to the Report: "An Assessment of the Michigan Accountability System,"[13] discussed in detail each of the recommendations made by the National Education Association and by the Michigan Education Association sponsored evaluation cited above.

In defense of the MEAP, John Porter, at that time the State Superintendent of Public Instruction, indicated that there was a need for every pupil testing in order to report to parents. He stated that the purpose of the MEAP was "to assess what educational attainments and deficiencies exist[ed] in order to build upon the attainments and to reduce the deficiencies."[14] He felt that there was a need to agree on what should be taught and to supply this information to all parents. He was convinced that the MEAP could provide the type of information needed by educators in order to improve instructional planning.

In a series of articles in the Michigan School Board Journal, Herbert C. Rudman discussed the 1976-77 MEAP. In the first article,[15] he indicated that the MEAP data were readily available and should have been used by local school boards for making local decisions. The second article[16] analyzed the MEAP objectives. The reading objectives were criticized on the grounds that there was no progression from the Grades 1 to 3 objectives to the Grades 4 to 6 objectives. However, the mathematics objectives did not suffer from this flaw. In the third article,[17] the item statistics were criticized. Rudman indicated that few of the items on the test had item difficulty indices (p-values) high enough to assure attainment by 80% or more of the students. A common profile for the five items used to measure an objective on the test was three difficult and two easy items. The changes in grade four reading items resulted in improved scores at that level between the 1975-76 and the 1976-77 testings. In the fourth and final article of the series,[18] Rudman warned that the MEAP had narrowed its focus to minimal reading and mathematics skills and advised against improper comparisons among groups based upon this narrow focus.

Paula Briotson traced the development of the old version of the Grade 10 MEAP test in a 1977 Michigan School Board Journal article.[19] She indicated that early field test results showed the reading items written for this test to be better than the mathematics items. These findings led to revisions of the mathematics items by Michigan mathematics educators.

Robert G. Clason of the MCTM discussed the organization's role with the MEAP in an article in The Mathematics Teacher.[20] The MCTM had been involved with MEAP since 1970, providing technical assistance and input into policy decisions concerning the MEAP. Clason indicated that the MCTM was involved in the selection of the objectives to be tested on the MEAP mathematics tests and also had input into the criteria for minimal competency used on the tests and that the MCTM had produced four monographs related to the MEAP. A concern expressed by Clason was the lack of information which would result from the administration of the MEAP tests once most students had attained the objectives being assessed. Another concern expressed in this article was that the Grade 10 objectives were neither a necessary nor a sufficient condition for high school graduation but that the fact that the MEAP was a state sponsored program gave the public the impression that when students achieved the objectives assessed on the Grade 10 MEAP test, the state was certifying them as competent. Clason defended the MCTM's participation in the MEAP program as an "attempt to shape an undeniably potent educational force."[21]

The MCTM produced a position statement on basic skills[22] which was published by the National Council of Teachers of Mathematics. The MCTM position statement on basic skills appeared in The Mathematics Teacher which addressed several aspects of the MEAP. This position statement indicated that, while the objectives of the MEAP were testable, and could be achieved, they were not developmental in nature and were not properly sequenced. The MEAP was criticised for summarizing the objectives and for informing local schools as to what subset of the MEAP objectives would be tested, thus allowing them to focus instruction on only a small subset of the objectives. The MCTM argued in this position statement on basic skills that meeting minimal objectives should not be a criterion for a quality mathematics program. Quality programs should include objectives and programs for mathematically talented students as well. MEAP did not address the concerns of these students. Local school districts were encouraged to develop their own instruments to fill this need.

Terrence G. Coburn discussed the use of the MEAP in curriculum planning in an article in The Arithmetic Teacher.[23] He felt the impact of the MEAP on the mathematics curriculum had been minimal. He observed that objectives on which students continually failed to perform well should have been re-evaluated. If they were still considered to be minimal, they should have resulted in curriculum reform.

In a recent update from the MDE on reporting MEAP test results,[24] Edward D. Roeber, David L. Donovan, and Richard T. Cole discussed how state assessment data could be released without damage to local school districts. These data were released to the public based on the assumptions that: (1) the public had the right to know about local achievement levels of public schools; (2) the public had the right to know what educators were doing to remedy problems; (3) it was better to give test results to the public than to have them discovered; (4) more data about achievement was needed to put test scores in perspective; and (5) a state agency could help in efficient reporting.

The MDE's program to help local districts had six components: (1) six regional conferences held as staff training sessions; (2) a full day statewide conference held for public relations officers from local districts; (3) briefings held for the media by the State

Superintendent; (4) discussions, with local superintendents, of relations with news media; (5) a survey and compilation of news reports on the MEAP; and (6) a report of the evaluation to the State Board of Education. The authors felt that these steps ensured proper reporting of MEAP results by the press.

Several doctoral dissertations have focused on various aspects of the MEAP.

Rae Marie Levis[25] found that when input variables collected as part of the 1971-72 MEAP test of seventh grade students were used as inputs to a multiple regression model, they produced equations which added to the information about factors which could be used to predict student achievement. The two variables which improved prediction to the greatest extent were socio-economic status (higher socio-economic status districts had higher MEAP scores) and percent of minority students in the district (districts with higher percentages of minority students had lower MEAP scores).

In a somewhat related study, Wolfe[26] used 1970 census data to construct demographic variables for school attendance areas. These data were then matched with school fourth and seventh grade 1970-71 MEAP results. The socio-economic status factors constructed from the census data had a higher correlation with MEAP scores than the MEAP socio-economic status variables used in the previous study.

Five constructs were found to predict MEAP school achievement at the ninety-five percent confidence level. They were: (1) labor force participation by women; (2) one or more moves per year; (3) above average number of children in the family (these three had negative correlations); (4) above average number of years of school completed by male parents; and (5) above average number of years of school completed by female parents (which were positively correlated with MEAP achievement).

Suttner[27] looked at similar variables in a non-public (Catholic) school setting. His findings were comparable to Levis' and Wolfe's in that race and surrogates for socio-economic status (tuition expenditures per pupil, urban vs rural location, and income levels) were found to significantly relate to mathematics and reading scores on the 1973-74 MEAP test for students in the seventh grade in Catholic schools in the Archdiocese of Detroit.

Aquino,[28] in 1974-75, surveyed fourth and seventh grade teachers across the state of Michigan concerning their attitudes toward the MEAP. His findings indicated that most teachers used the results for identifying instructional needs of students. Some problems in the area of dissemination of results were identified. Most responders indicated positive attitudes toward the materials they received related to the MEAP.

Steele[29] investigated principals' attitudes toward the MEAP and use of MEAP results. Questionnaire survey results indicated that principals received MEAP results and shared them with teachers. Principals also used results as an indication of school achievement level, and as an indicator of curricular strengths and weaknesses. Principals indicated favorable attitudes toward the MEAP and felt the program should be continued.

Strong[30] assessed teacher attitudes related to the MEAP reading objectives. He found disagreement between teacher ratings of objectives and the MDE's position that MEAP reading objectives were minimal. Teachers felt that some MEAP objectives were not minimal. Teacher ratings of objectives differed by experience level and school district classification. No significant relationship was found between teacher ratings of objectives and the attainment of these objectives by students.

Willard[31] conducted a formative evaluation of the 1975-76 MEAP Kindergarten Special Study to provide the MDE with information on the design and implementation of the Kindergarten Special Study, its impact on teacher's instruction, on intra-school communication, and on communication between the school and home. Several survey instruments were used to get the opinions of participating teachers and a subset of subjects were interviewed. MEAP tests and observations were also used as part of the evaluation study. The findings of the evaluation study included the following recommendations:

1. The objectives should be revised.
2. Reporting forms needed to be revised to make them less time consuming.
3. Program procedures needed consolidation and revision.
4. Inservice education to clarify participant roles and underlying concepts should be initiated.
5. The multiple assessment mode should be maintained.

McCormick[32] documented three controversies surrounding the MEAP during the period from 1969-1977. The first controversy arose between the MDE and the Michigan Association of School Administrators, and centered around the comparisons made among school district results on the 1969-70 MEAP which were interpreted as measures of school quality. The second controversy occurred in 1972 and involved five reports issued by the Michigan Association of Professors of Educational Administration's Task Force on Accountability which were critical of the MEAP test construction and the involvement of the Educational Testing Service. The third issue concerned an evaluation report by House, Rivers, and Stufflebeam which was contracted for by the Michigan Education Association and the National Education Association in 1974. This report was critical of the accountability model and the MEAP.

Factor Analysis

Factor analysis was the major data analysis technique used in this study. Major works related to the theory and interpretation of factor analytic studies are discussed in this section.

Cattell suggested that the purpose of factor analysis was "to represent or explain observed covariational relations among many experimental variables in terms of linear dependencies on, and relations among, a much reduced number of 'ideal,' 'intervening' or 'abstract' conceptual variables."[33] He noted that since this was the purpose of science, factor analysis may be considered the ultimate scientific method. The factor analytic procedure permits the interpretation of a large number of variables as a smaller number of underlying concepts.

This procedure requires several steps. First, initial orthogonal unrotated factors are extracted from the correlation matrix. Once this has been accomplished, Cattell indicated that the alternatives consist of a choice between one closed and two open models:

> Model 1, a closed model, where all variances are considered to be accounted for by a set of common factors and where there are as many common factors as there are variables, is usually called "component analysis;"
>
> Model 2, an open model, where the variance is accounted for by a set of common factors (which may be correlated) as numerous as the

> number of variables and an equal number of specific (uncorrelated) factors, is called the "free general factor analysis model;" and
>
> Model 3, an open model, where the variance is accounted for by a set of common factors (which may be correlated) larger in number than the number of variables, and a set of specific factors equal in number to the number of variables, is called an "approximating factor analysis model."

Cattell[35] also pointed out that rotation must be considered since, without rotation, the resulting factor pattern rests upon an accident of the extraction process and the particular choice of variables. Cattell also indicated that he felt that oblique rotation is the only scientifically acceptable model since all factors exert influences upon each other in the real world.

The notion of rotation to simple structure was discussed by Cattell[36] as one method for discovering the underlying factor structure. Simple structure is achieved when each factor has loadings extending over only a few variables, that is, when variables load on the smallest possible number of factors. Several computer programs which have been written to attempt to achieve simple structure were discussed by Cattell. These included three programs for orthogonal rotations: quartimax, varimax, and equimax, and three programs for oblique rotations: oblimax, oblimin, and binormamin. Oblique rotation is more likely to reflect the interrelationships among factors which Cattell indicated is the proper description of the actual condition in the real world.

Confactor rotation, a second method for discovering the underlying factor structure, was discussed by Cattell[37] in the same chapter. The confactor rotation method was based on the belief that if factors were determiners, then relations between factor loading patterns on two experimental occasions, using the same variables, should be proportional. Programs which used this method attempted to discover this proportionality between experiments and used this information to establish the unique position of the real influences.

Using factor analysis to test hypotheses about the structure of a data set was also discussed by Cattell.[38] Hypotheses which may be tested by factor analysis must state: the number of factors expected, the loading patterns, and the correlations expected among factors. Cattell's discussion of the use of factor analysis for hypothesis testing when the same subjects are involved in two studies indicated that it "is a matter of correlating factors or estimated factors directly."[39]

The question of the number of factors was also addressed by Cattell.[40] He indicated that the exact number of factors is at least as large as the number of variables, but due to the limitations of the statistical techniques involved, it is possible to extract at most as many factors as variables, even though more factors than variables may actually exist. Factors which are extracted consist of substantive and error factors. Error factors are the result of errors of measurement, not sampling error, and are not replicated across studies.

Three approaches to the question of when to stop factoring are: (1) to use the smallest number of factors which fit the hypothesized model, (2) to stop factoring when a mathematical limit has been reached (that is, a statistical limit), and (3) to use a criterion based upon rotation properties of the comprehensive non-trivial variance estimate.

One statistical approach suggested by Rao[41] and Lawley[42] is the maximum likelihood solution which varies the number of factors and sizes of estimates of communalities until a combination is achieved which restores the original correlation matrix within a statistically acceptable margin of error. Other statistical methods involve tests of the standard error of the factor loading.

Cattell's scree test, which graphs the latent roots of the factors and uses their relative size to determine when further factoring would probably produce error factors is an example of basing the decision of when to stop factoring on rotation properties. These methods "seek to take out all the variance, with a best communality estimate and, by rotation, to separate substantial measurement from error factors."[43]

Cattell[44] discussed two approaches to increase the precision of estimating communalities and determining the number of factors. The first was image analysis which was introduced by Guttman[45] and amplified by Kaiser.[46] Image analysis fixes an exact factor space by using the square of the multiple correlation of each variable with all the others as its communality.

The second approach to increase precision discussed by Cattell was alpha factor analysis introduced by Kaiser and Caffrey.[47] This procedure uses the alpha coefficiant of homogeneity as a test for the correct number of factors. Alpha factor analysis is an iterative process which factors successive correlation matrices until the number of factors and the communalities converge.

On the subject of sample size, Cattell indicated that "one would hesitate to use factor analysis with fewer than 80 to 100 subjects.... Regarding the relation of number of referees, N, to number of relatives, n, a useful rule of thumb has grown up which states that the ratio of persons to tests....should be not less than 2-1/2 to 1. ....when one gets close to a square score matrix, one has insufficient information to define the correlations or, in spatial terms, to place the n axes determinately by the projections of the N individuals."[48]

With respect to assumptions about the distribution of the scores, Cattell[49] indicated that factor analysis makes no assumption of normality but that simple structure is clearer when scores are normal due to better scaling.

In light of its development by Pearson and later use by Spearman to classify individuals based upon measurable characteristics, Sir Cyril Burt[50] observed that, "it appears that the primary aim of factor analysis is exploratory."[51] Factor analysis is usually undertaken with hypotheses in mind which the statistical analyses tend to modify by revealing additional factors which were not hypothesized.

Kerlinger described the principal factors method of factor analysis as

> mathematically satisfying because it yields a mathematically unique solution of a factor problem. Perhaps its major solution feature is that it extracts a maximum amount of variance as each factor is calculated. In other words, the first factor extracts the most variance, the second the next most variance, and so on.[52]

With respect to rotation of factors to achieve simple structure, Kerlinger cited Thurstone's five rules for simple structure:

1. Each row of the factor matrix should have at least one loading close to zero.

2. For each column of the factor matrix there should be at least as many variables with zero or near-zero loadings as there are factors.

3. For every pair of factors (columns) there should be several variables with loadings in one factor (column) but not in the other.

4. When there are four or more factors, a large proportion of the variables should have negligible (close to zero) loadings on any pair of factors.

5. For every pair of factors (columns) of the factor matrix there should be only a small number of variables with appreciable (non-zero) loadings in both columns.[53]

Kerlinger described factor scores as "weighted sums or averages, the weights being the factor loadings"[54] which can be used as surrogates for larger numbers of variables in order to achieve greater reliability and validity of measures as well as to achieve parsimony.

Cooley and Lohnes described principal components analysis as "a generally useful procedure whenever the task is to determine the minimum number of independent dimensions needed to account for most of the variance in the original set of variables."[55] They defined factors as "derived measurement constructs that may have the virtues of parsimony, orthogonality, increased reliability, and increased normality over the observation measures from which they are derived."[56]

Cooley and Lohnes[57] discussed two methods of analytic orthogonal rotation of factors to simple structure: quartimax, which simplifies rows in the factor matrix by maximizing the squared factor loadings and varimax, which simplifies the columns. Varimax has become the most popular orthogonal rotation procedure since it simplifies factors, instead of variables. This procedure yields high loadings for a small number of variables and near zero loadings for the other variables.

Concerning the number of factors to be retained for rotation, Cooley and Lohnes observed that "it is usually desirable to retain enough factors for rotation to demonstrate that all major factors have been accounted for and that some nearly unique factors (significant loadings of only one test) have been reached. It is better to take too many rather than too few factors into rotation."[58]

Kim and Mueller discussed two fundamental postulates underlying the use of factor analysis:

> The postulate of factoral causation: Given relationships among variables, this postulate imposes a particular causal order on the data--the observed variables are linear combinations of some underlying causal variables.
>
> The postulate of parsimony: Given that both one-common factor and two-common factor models are consistent with the observed data, we accept on faith the more parsimonious model.[59]

In a subsequent paper, Kim and Mueller described the placement of principal component axes as follows:

> In general, the principal axis is given by a line from which the sum of the squared distances from each point is a minimum value. ...Once the first component is defined in such a way that the most information is contained in it

> (it explains the largest amount of variance in the data), the second component is defined in a similar way with the condition that its axis is perpendicular to the first... Principal components analysis['] ... objective is not to explain the correlations among variables, but to account for as much variance as possible in the data.[60]

They pointed out that the sum of the eigenvalues is equal to the number of variables and their product is equal to the determinant of the correlation matrix. The quotient of the eigenvalues and the number of variables gives the proportion of variance explained by their corresponding principal component axis; the principal component loadings may be found by multiplying the eigenvectors by the square root of their respective eigenvalues.

Kim and Mueller further pointed out that there is a fundamental difference between factor analysis which "represents the covariance structure in terms of a hypothetical model, [and] components analysis [which] summarizes the data by means of a linear combination of the observed data."[61] Principal components does not require this causal model and, therefore, is not able to reveal an underlying causal structure if, indeed, one exists.

According to Kim and Mueller,[62] principal axis factoring applies principal components analysis to the adjusted correlation matrix. This adjustment consists of replacing the 1's in the diagonal with corresponding estimates of communalities derived from the squared multiple correlations of each variable with the others in the set.

Kim and Mueller[63] also pointed out that the initial factors extracted by principal components or any other method are arbitrary and have two likely problems relative to interpretation: (1) the complexity of the factors is probably greater than one, and (2) the factors extracted after the first factor are bipolar. These problems are solved by rotation, the basic goal of which is, "to find a factor pattern matrix that is closest to the simplest ideal structure,"[64] that is, simple structure.

Two methods of orthogonal rotation were discussed by Kim and Mueller:[65] quartimax, which tends to emphasize simple variable interpretation at the expense of simple interpretation of factors, and varimax, which maximizes the variance of squared loadings for each factor. They also discussed oblique rotations. The oblique rotation, which allows factors to be correlated, parallel in criterion to quartimax is called quartimin, which tends to produce more oblique factors, while the oblique rotation parallel in criterion to a varimax is covarimin, which tends to produce fewer oblique factors when both are applied to the same data set. These two rotations were special cases of the more general oblimin criterion for oblique rotation with quartimin producing the most oblique rotation and covarimin the least oblique. Oblimax was also mentioned as being equivalent to quartimax in orthogonal rotation but producing a different solution than quartimin when factors are allowed to be correlated.

Kim and Mueller[66] discussed the problem of the number of factors that should be extracted. Five alternatives were addressed: (1) significance tests, which involve using a X^2 test associated with the maximum likelihood solution (which tends to produce more factors than the researcher finds convenient to use); (2) eigenvalue specification, where factors with eigenvalues greater than one are retained when the unadjusted correlation matrix is decomposed (a useful technique which gives expected results in Monte Carlo studies); (3) substantive importance, where the proportion of the total variance is used as a criterion for the number of factors (this method tends to be subjective in that the researcher determines the criterion); (4) Cattell's Scree Test, which involves graphing the eigenvalues and ceasing to factor at the point where these values level off to form an almost horizontal line; and (5) interpretability and invariance, a combination of several rules which states that, "given the complexity as well as uncertainties inherent in the method, the final judgement has to rest on the reasonableness of the solution on the basis of current standards of scholarship in one's own field."[67] That is, the results of factor analytic studies must make sense to other researchers and must be stable across studies.

Kim and Mueller[68] described component scores as factor scales which were the result of principal component analysis rather than factor analysis which assumed the existence of underlying factors as described above. These component scores were obtained from the results of mathematical combinations of the raw variables with weights that are proportional to their component loadings. Kim and Mueller indicated that these scores had legitimate uses in practical research and were preferred when "the objective is some simple summary of information contained in the raw data."[69]

Horst observed that factor analysis "plays a critical role in psychological measurement and in the definition of things to be measured."[70] He continued, "[F]actor analysis enables us to judge which of a large number of arbitrarily specified and defined variables may be usefully regarded as the fundamental variables of a set."[71]

Horst described factors as "the number of basic variables necessary to account for the observed measures within a specific degree of accuracy.... Essentially, factor analysis provides a formal and well structured mathematical and statistical basis for specifying the minimum number of concepts required to describe observed phenomena with a specified degree of accuracy."[72]

Horst defined four types of factors: (1) general factors, which have loadings from all tests under analysis; (2) common factors, which have loadings from several, but not all, of the tests under analysis; (3) specific factors, which have a loading from only one variable; and (4) error factors, which are additional factors required to account for discrepancies between the approximation of the correlation matrix which can be reconstructed from the factor matrix and the correlation matrix which is constructed from the original data.

According to Horst, "The factor loading of a test on a particular factor is the correlation of that test with the factor....if the factor analysis is performed on the correlation matrix."[73]

In an earlier, more technical work,[74] Horst discussed five objectives of factor analysis. These objectives were: (1) to determine the dimensionality of the system: the number of factors which may describe the data set; (2) to determine the primary variables of the system: choosing the best set of underlying factor variables which describe the data set; (3) factorial invariance: the extracted factors should not vary across samples; (4) factor analysis and prediction: using factor analytic techniques to reduce the number of predictor variables required to efficiently predict criterion variables without capitalizing on error variance; and (5) facilitation of interpretation: defining and labeling primary variables which may be used across studies to increase understanding of results.

According to Harman,

> Factor analysis addresses itself to the study of interrelationships among a total set of variables, no one of which is selected for a different role than any of the others. In some sense all variables in such a study are construed to be dependent, with the independent variables being the new hypothetical constructs called factors.[75]

Harman distinguished between the classical model for factor analysis in which group or common factors, specific, and error factors are included in the results, and component analysis in which variables are broken down into only common factors. He discussed Thurstone's criteria for simple structure and factor scores. Principal factor solutions and maximum likelihood solutions were described by Harman as direct solutions to the factor problem. Indirect solutions discussed by Harman were orthogonal multiple-factor solutions and oblique multiple-factor solutions.

Harman also expressed caution on the abuse of factor analysis since its use has become greatly simplified by computers:

> With proper use of the technique and of the computer, factor analysis provides a most effective means for studying and synthesizing the multidimensional characteristics of a wide variety of data in social sciences.[76]

Maxwell discussed principal component analysis and its practical applications:

> One of the most important and most straightforward of [which] is for data reduction... [A] principal component analysis is straightforward in the sense that no distributional assumptions need be made about the observed variates, nor is it necessary _en route_ to try to interpret the components derived from them.[77]

He further cautioned that "since a component analysis is not invariant under changes of scale in the variates, it is most appropriately used when the latter are all measured in the same metric and have variances of similar magnitude."[78]

Maxwell distinguished between factor analysis and principal component analysis as follows: "In factor analysis, unlike principal component analysis, an hypothesis about the covariance (or correlational) structure of the variates is implied."[79] He further indicated that

> It is helpful to note that in a preliminary investigation of the correlational structure of a set of data the first few principal components, especially when they account for a fairly high percentage of the total variance of the variates are likely to provide a good overall picture. Rotation of them too by, say, the varimax method may be of additional help in detecting subgroups of variates which are especially related to each other. But... if the variances of the variates are greatly inflated by error the component weights may be spuriously large, for the first component will have extracted a maximum of the _total variance_ (true and error), and

> succeeding components a maximum of the 'variance' which remains. It is incorrect to assume, as often seems to be the case, that error variance is reflected only in the smaller latent roots of a matrix, that is in the components which normally are discarded. Error variance is effectively eliminated only in a model which makes specific allowance for it, as is the case in the factor model.[80]

Mulaik[81] traced the history of factor analysis beginning with Galton's study of individual differences. Galton's work led to his collaboration with Pearson which produced regression equations and correlation coefficients in an effort to explain Galton's findings. Fisher later used Pearson's correlation coefficients to test hypotheses concerning genetics and developed partial correlation and multiple correlation methods which eventually led to the development of factor analysis.

According to Mulaik, Spearman developed the concept of a general ability and several specific abilities in order to explain human intelligence. Cyril Burt and Phillip Vernon took the view that there was a hierarchy of mental abilities from general to specific and that correlations among abilities depended upon common group factor variables as well as a general ability variable. Thurstone developed the method of multiple factor analysis and rules for simple structure of the rotated factor matrix. His view of human intelligence was that no general factor existed. Instead, he looked for a set of factors which conformed to the rules of simple structure and used these factors as his model.

Mulaik continued his historical account by indicating that factor analysis became easier to use with the use of computers in the 1950's and 1960's. During this period, Mulaik indicated that factor analysis was blindly applied to all types of data in the hope that order would emerge from seemingly unrelated data. During the late 1960's, the use of factor analysis for hypothesis testing was emphasized. Mulaik projected that developments in this area would facilitate the development of structural theories in psychology.

Following the historical account of the development of factor analysis, Mulaik described the mathematical basis for factor analysis, methods of factor extraction, common factor analysis, component analysis, image factoring, rotation (oblique and orthogonal), factor scores, factorial invariance, and confirmatory factor analysis.

Mulaik indicated that principal components analysis

> concentrates upon analyzing the variables into a linearly independent set of component variables from which the original variables can be derived.... Moreover, being a completely determinate model, component analysis can directly compute factor scores without the need to estimate them, as in common-factor analysis. This feature is a particular advantage in some studies where scores on factors are needed... Component analysis is especially useful in its own right when the objective of the analysis is not to account for just

> the correlations among the variables but rather to summarize the major part of the information contained in them in a smaller number of (usually orthogonal) variables.[82]

Mulaik went on to say that,

> The advantages of [principal-components analysis] over the diagonal method or centroid method lie in the mathematical convenience of working with eigenvalues and eigenvectors to determine the number of factors to retain and to compute factor scores.[83]

According to Cooley and Lohnes, principal-components analysis accomplishes the task of producing "a composite score measuring what [several] variables have in common and producing a maximum variance among individuals. This is accomplished by projecting all points perpendicularly onto the principal axis of the elipsoid"[84] which represents the scatterplot of the variables. They discussed the mathematics involved in principal-components analysis, defined simple structure using Thurstone's criteria, and described the computation of factor scores.

Gorsuch[85] defined principal factors as the procedure used to factor analyze a correlation matrix when each factor is based upon the correlations among the total set of variables. He indicated that when the principal components procedure is applied to a correlation matrix with estimated communalities in the diagonal, common factors result. The results are called principal axes.

Gorsuch indicated that,

> When the number of common factors can be assumed, another procedure [for extracting principal components] is that of iterating for communalities. Simple communality estimates are first entered into the diagonal of the correlation matrix and the appropriate number of principal factors extracted. The observed communality is then calculated for the resulting factor structure by summing the squared loadings for each variable. The observed communality will be somewhat different from the original estimates and are generally closer to the 'true' communalities. The observed communalities calculated from the principal factor solution are then inserted into the diagonal of the correlation matrix and a second set of principal factors extracted. A new set of observed communalities is then calculated from the second factor analysis and these communalities become new estimates to be entered into the diagonal of the correlation matrix.[86]

This procedure continues until the observed change in the communalities is smaller than a pre-set criterion.

On the subject of relating factors across studies when the same individuals but different variables are under analysis, Gorsuch indicated that, "If the question is one of determining if the same factors occurred in the two domains, then correlations between the factor scores form an appropriate method of relating factors."[87] He cautions, however, that perfect correlations occur only if no changes in the individuals occur between the two times data are collected. Any shift in the characteristics of the individuals being studied will result in lower correlations.

Gorsuch's procedure for

> Matching factors generally proceeds by starting with the two factors which have the highest correlation. The two factors are considered a match. Then the next highest correlation is sought and these two factors are considered a match. The process continues until all of the factors are matched or the correlations are too low to warrant matching.
>
> Problems may arise in that the same factor may correlate quite well with two factors in the other study or may not correlate well with any factor in the other study. Then... it can simply be reported that alternative matches exist or that no match exists....
>
> [I]f low correlations among the factors exist the nature of the measuring instruments might have shifted.[88]

Guertin[89] used a variety of factor analytic methods and different communality estimates on a set of data, which involved eight variables and two factors, which were derived from physical body measurements. All methods used gave similar results after the resulting factor matrix was rotated to the varimax criterion. Principal components, image covariance analysis, and more traditional methods all resulted in the same factor structure for these data. Guertin concluded that results for the newer methods of factor analysis were not substantially different from those obtained by older procedures.

Morris and Guertin[90] compared canonical correlation methods to factor analysis for relating underlying constructs across variables. After comparing the results of the two procedures, when they were applied to extant data sets from the social sciences, they found common factor analysis to be valuable as a method for relating underlying constructs across sets of variables.

In a later Monte Carlo study,[91] Morris and Guertin compared common factor scores to unfactored data-level variables as predictors in terms of the correlation of a criterion with the predicted variable in multiple regression equations. The computer generated data for this study consisted of three populations which differed in the level of common variance among their predictor variables. Two replication populations were generated for each of the three original common variance levels which differed from the original by specific amounts in their intercorrelation matrices. The results indicated that factor scores were better predictors than data-level variables, especially where there was a very high or very low level of common variance and where the replication population was most different from the original population. They also found that factor scores tended to be more stable than data-level variables at all levels of common variance and difference of replication population.

Morris and Guertin have also published a FORTRAN computer program[92] which cross-correlates least squares estimated factor scores across separately factor analyzed variable domains without actually computing factor scores.

Summary

This review of related literature has summarized state sponsored MEAP publications, examined studies related to the MEAP, and presented various points of view on the theory and use of factor analysis as a statistical technique, especially as it relates to relating underlying factors across sets of variables.

None of the studies reported here examined the factor structure of any of the MEAP test instruments. In addition, most of the studies dealt with either the grade four or grade seven MEAP test.

The factor analysis literature suggested that principal components analysis was the appropriate factor analytic technique to employ in this study. Rotation to simple structure using the varimax criterion was also recommended by many researchers. To relate the factors from the two tests, the literature indicated that correlations among factor scores would be the most appropriate technique for this study, since the same individuals were involved in the administration of the two versions of the Grade 10 MEAP Mathematics Test.

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CHAPTER III

Methods and Procedures

The methods and procedures used to address the questions posed in Chapter I are described in this chapter.

Subjects

The subjects were 557 Grade 10 students in five volunteer high schools. The high schools selected represented five of the six major community types identified by the Michigan Department of Education: Southeast Metro, Outstate Metro, Outstate Rural, Southeast Suburb, Outstate Suburb, and Northern. A list of these schools, the location of each school, and the number of students participating from each school may be found in Appendix B. Each of the five schools administered the old version of the Grade 10 Michigan Educational Assessment Program (MEAP) mathematics test in addition to the new version of the MEAP test. The order of administration was at the discretion of the local school. All schools administered the new version first followed approximately three weeks later by the old version of the test.

Instrumentation

The instruments used in this study were two versions of the Michigan Educational Assessment Program Grade 10 mathematics test: the old (1979) version of the test and the new (1980) version of the test. Each of these instruments was an objective-referenced test which was based upon sets of minimal performance objectives for students at the beginning of Grade 10. Members of the Michigan Council of Teachers of Mathematics were instrumental in writing the original set of mathematics objectives and in editing and revising the items for the old and new versions of the test.

The old version assessed 40 objectives classified in ten skill areas. Each of the four forms of the new test assessed 35 objectives, 28 core objectives and seven correlates. Only the 28 core objectives common to all four forms were included in the proportions report. Data from the proportions report were used as a basis for equating the two tests and for viewing longitudinal data on schools and school districts. The 28 core objectives on the new test were classified in nine skill areas.

Since these were objective-referenced instruments, traditional measures of validity and reliability were not appropriate and were not available. Due to the fact that the objectives and items for both instruments were thoroughly scrutinized by a large number of Michigan mathematics teachers in formal sessions where items were criticized and revised, it would seem appropriate to conclude that these instruments possessed a reasonable degree of content validity.

With respect to reliability of an objective-referenced instrument, it is generally accepted that the larger the number of items per objective the higher the reliability. Since the new test reduced the number of items per objective, this would appear to have been detrimental to the reliability of the new instrument. The work of Bauer and others indicated that, for Grade 4 reading, at least, this may not have been the case. In addition, preliminary studies conducted by the Department of Education indicated that the proportions report classification for students on the old and new test differed very little. These findings tended to support the reliability of the new test in terms of the old one.

Data Collection Procedures

Data were collected from five high schools located throughout the state. These schools volunteered to administer the old version of the Grade 10 MEAP mathematics test along with the regular administration of the new version of the MEAP test in the fall of 1980. Students at these five sites took the entire new version Grade 10 MEAP test (both mathematics and reading) during the state-wide administration of the test. They then took the mathematics part of the old version of the Grade 10 MEAP test approximately three weeks later. Completed answer sheets for both tests were forwarded to a scoring service for machine scoring. A computer tape containing individual pupil data for both instruments was produced from these answer sheets. A copy of the data tape was released to the researcher by the Michigan Education Assessment Department.

Data Analysis Procedures

The initial analysis of the data in this study involved the computation of four Pearson product-moment correlation coefficients. The first measured the relationship between the number of items each student answered correctly and the number of objectives (s)he achieved on the old version of the Grade 10 MEAP mathematics test. The second measured the relationship between the number of items each student answered correctly and the number of objectives (s)he achieved on the new version of the Grade 10 MEAP mathematics test. The third measured the relationship between the total scores (number correct) on each of the two tests. The fourth measured the relationship between the total number of objectives achieved on the two tests.

The second phase of this study involved scoring of the tests. For the old version of the test, four items were used to assess each objective. An objective score of 0 through 4 was assigned to each of the 40 objectives on the old version of the test based upon the number of items correctly answered. Each subject had 40 objective scores, each ranging from 0 through 4. For the new version of the test, three items were used to assess each objective. An objective score of 0 through 3 was assigned to each of the 28 core objectives on the new version of the test based upon the number of items correctly answered. Each subject had 28 objective scores, each ranging from 0 through 3.

The third phase of the study involved a series of exploratory factor analyses. First, a correlation matrix among objective scores was produced. For each exploratory factor analysis, initial factors were extracted, employing an iterative principal-component solution, which were rotated to simple structure using the varimax criterion. Factors were named based upon which objectives had significant loadings on them. Factor scores were computed for each student based upon the terminal factors extracted in each factor analysis. Pearson product-moment correlation coefficients were computed on all pairs of factor scores in order to match factors from different domains.

The final phase of the data analysis involved the compilation of proportions data, using the state proportions report categories for the sample students in order to determine what decisions would be made based upon the old and new versions of the test.

CHAPTER IV

Results

This chapter contains the results of the data analysis outlined in Chapter III.

This study examined the factor structure of two versions of the Grade 10 MEAP mathematics test. The subjects were 557 grade ten students from five volunteer high schools who took the new (1980) version of the Grade 10 MEAP test during the regularly scheduled administration period in the fall of 1980 and then took the old (1979) version of the Grade 10 MEAP mathematics test approximately three weeks later.

The old and new versions of the Grade 10 MEAP mathematics test varied in several aspects. The old form tested 40 objectives using four items per objective with a criterion for success of at least three correct while the new form tested 28 objectives using three items per objective with a criterion for success of at least two correct. The two forms shared 14 common objectives with three identical items on each version of the test to measure those objectives. The old version had one additional similar item for each of the 14 objectives.

Data for this study were obtained from the Michigan Research, Evaluation and Assessment Services Department. All data analyses were conducted at the Wayne State University Computing Services Center using the Statistical Package for the Social Sciences (SPSS) and FORTRAN programs written by the researcher.

Correlational Analyses

The initial analysis of the data involved the computation of four Pearson product-moment correlation coefficients. The results appear in Table 1. All were significant at α =.01.

The first correlation coefficient measured the relationship between the number of items each student answered correctly and the number of objectives (s)he achieved on the old Grade 10 MEAP mathematics test. The result of this analysis was a value of r=+.9805. The second correlation coefficient measured the relationship between the number of items each student answered correctly and the number of objectives (s)he achieved on the new Grade 10 MEAP mathematics test. The result of this analysis was a value of r=+.9833. The third correlation coefficient measured the relationship between the total score (number correct) on each of the two tests.

The result of this analysis was a value of r=+.7991. This coefficient represented a classical alternate forms reliability coefficient. The fourth correlation coefficient measured the relationship between the number of objectives achieved on the two versions of the test. The result was a value of r=+.8072. This coefficient represented a reliability coefficient based upon the objective scores.

TABLE 1

PEARSON PRODUCT-MOMENT CORRELATION COEFFICIENTS RELATING NUMBERS OF OBJECTIVES ACHIEVED AND NUMBERS OF ITEMS CORRECT ON THE OLD (1979) AND NEW (1980) GRADE 10 MEAP MATHEMATICS TESTS (N = 557)

Variables Correlated	Correlation Coefficient	
Number of objectives achieved with number of items correct.	r = +.9805*	(Old Test)
	r = +.9833*	(New Test)
Number of items correct: old test with new test.	r = +.7991*	
Number of objectives achieved: old test with new test.	r = +.8072*	

*p = < .01

First Factor Analysis of the New Version

The factor matrix resulting from the iterative principal components analysis followed by varimax rotation of the new version of the Grade 10 MEAP mathematics test appears in Appendix C, Table C-1. The initial principal components analysis produced three factors with eigen-values greater than one which were then rotated to simple structure using the varimax procedure. The objectives are arranged according to factor loading. The highest loading for each factor is contained in a rectangle. Objective names are those used by the MEAP. These three factors, together with the objectives loading on them, are presented in Figure 1.

Factor I was identified as Fractions, Algebraic Operations and Formulas. The objectives with the highest loadings on Factor I were: adding fractions with different denominators, addition word problems, subtract mixed numbers with unlike denominators, subtract fractions with unlike denominators, whole numbers times mixed numbers, evaluate common algebraic expressions, area word problems, convert mixed numbers to common fractions, volume computations, angle measurement, and parts of a circle.

Factor II was identified as Decimals. The objectives with the highest loadings on Factor II were:

FIGURE 1

FACTORS RESULTING FROM THE PRINCIPAL COMPONENTS ANALYSIS AND VARIMAX ROTATION OF THE 28 OBJECTIVES ASSESSED ON THE NEW (1980) VERSION OF THE GRADE 10 MEAP MATHEMATICS TEST

Factors Number/Name		Objectives Loading On Each Factor
I	Fractions, Algebraic Operations and Formulas	Adding fractions with different denominators
		Addition word problems
		Subtract mixed numbers with unlike denominators
		Subtract fractions with unlike denominators
		Whole number times a mixed number
		Evaluate common algebraic expressions
		Area word problems
		Convert mixed numbers to common fractions
		Volume computation
		Angle measurement
		Parts of a circle
II	Decimals	Multiply fractions
		Word problems: multiplication of decimals
		Word problems: find percentage of a given number
		Order a set of decimals
		Money word problems
		Decimal divided by a whole number
		Find the mean of a set of numbers
		Probability of a simple event
		Decimal divided by a decimal
III	Division	Word problems: whole number division
		Computation: whole number division
		Time conversion
		Convert fractions to decimals
		Read a coordinate system
		Decimal times a decimal
		Find the larger of two fractions
		Convert fractions, decimals, percents

multiply fractions, word problems: multiplication of decimals, word problems: find percentage of a given number, order a set of decimals, money word problems, decimal divided by a whole number, find the mean of a set of numbers, probability of a simple event, and decimal divided by a decimal.

Factor III was identified as Division. The objectives with the highest loadings on Factor III were: word problems: whole number division, computation: whole number division, time conversion, convert fractions to decimals, read a coordinate system, decimal times a decimal, find the larger of two fractions, and convert fractions, decimals, percents.

First Factor Analysis of the Old Version

The factor matrix resulting from the iterative principal components analysis followed by varimax rotation of the old (1979) Grade 10 MEAP Mathematics Test appears in Appendix C, Table C-2. The initial iterated principal components analysis produced five factors with eigenvalues greater than one which were rotated to simple structure using the varimax procedure. These five factors, together with the objectives loading on them, are presented in Figure 2.

Factor I was identified as Arithmetic: Whole Number and Decimal Multiplication and Division. The objectives with the highest loadings on Factor I were: answer questions using a bar graph; decimal times a decimal; word problems: standard units of measure; given cost, what could be purchased; whole number division: computation; find the larger of two fractions; convert common fractions to decimals; determine the percentage of a given number; word problems: rectangles, triangles, circles; parts of a circle; and find a set of equivalent fractions.

Factor II was identified as Algebraic Operations and Fractions. The objectives with the highest loadings on Factor II were: add mixed numbers; subtract mixed numbers; subtract fractions; evaluate common algebraic expressions; decimal times a power of ten; whole number times a fraction; locate integers on a number line; solve linear equation; find the mean of a set of numbers; whole number times a mixed number; decimal divided by a decimal; add integers; write exponential expression as a product; and round to the nearest one, tenth, hundredth.

Factor III was identified as Ratio, Proportion, Percent and Probability. The objectives with the highest loadings on Factor III were: multiply or divide money by a positive integer; read a coordinate system; write ratio describing indicated comparison; locate items in a table of data; order a set of decimals; convert fractions, decimals, percents; predict number of times an event will occur; and word problems: find percentage of a number.

FIGURE 2

FACTORS RESULTING FROM THE PRINCIPAL COMPONENTS ANALYSIS AND VARIMAX ROTATION OF THE 40 OBJECTIVES ASSESSED ON THE OLD (1979) VERSION OF THE GRADE 10 MEAP MATHEMATICS TEST

Factors Number/Name		Objectives Loading On Each Factor
I	Arithmetic: Whole Number and Decimal Multiplication and Division	Answer questions using a bar graph Decimal times a decimal Word problems: standard units of measure Given cost, what could be purchased Whole number division: computation Find the larger of two fractions Convert common fractions to decimals Determine the percentage of a given number Word problems: rectangles, triangles, circles Parts of a circle Find a set of equivalent fractions
II	Algebraic Operations and Fractions	Add mixed numbers Subtract mixed numbers Evaluate common algebraic expressions Decimal times a power of ten Whole number times a fraction Locate integers on a number line Solve linear equation Find the mean of a set of numbers Whole number times a mixed number Decimal divided by a decimal Add integers Write exponential expression as a product Round to the nearest one, tenth, hundredth

(more)

FIGURE 2--Continued

Factors Number/Name		Objectives Loading On Each Factor
III	Ratio, Proportion and Probability	Multiply or divide money by a positive integer Read a coordinate system Write a ratio describing an indicated comparison Locate items in a table of data Order a set of decimals Convert fractions, decimals, percents Predict number of times an event will occur Word problems: find percentage of a number
IV	Metric Measurement	Find the perimeter of polygons and circles Write equivalent ratios by supplying the missing whole number Measure objects to nearest unit Measure triangle and find area
V	Non-Metric Measurement	Identify congruent and non-congruent figures Find the difference in time intervals Multiply fractions

Factor IV was identified as Metric Measurement. The objectives with the highest loadings on Factor IV were: find the perimeter of polygons and circles; write equivalent ratios by supplying the missing whole number; measure objects to nearest unit; and measure triangle and find area.

Factor V was identified as Non-Metric Measurement. The objectives with the highest loadings on Factor V were:

identify congruent and non-congruent figures, find the difference in time intervals, and multiply fractions.

Factor scores were computed for each of the 557 students based upon the three New Test factors and the five Old Test factors. Pearson product-moment correlation coefficients were computed on all pairs of sets of factor scores. The resulting correlation matrix appears in Appendix C, Table C-3. A summary of the intercorrelations among the factor scores is provided in Figure 3.

FIGURE 3

SUMMARY OF THE INTERCORRELATIONS AMONG FACTOR SCORES ON THE OLD (1979) AND NEW (1980) VERSIONS OF THE GRADE 10 MEAP MATHEMATICS TEST

Old (1979) Version Factors	New (1980) Version Factors		
	Factor I	Factor II	Factor III
Factor I	0.3214	0.2944*	0.1847
Factor II	0.6460*	0.2234	0.3854*
Factor III	0.0798	0.2792*	0.1717
Factor IV	0.4102*	0.1443	0.1871
Factor V	0.0534	0.0885	0.3096*

*Asterisks indicate the highest intercorrelations among factor scores.

The results of these correlational analyses indicated that Factor I from the new test, Fractions, Algebraic Operations and Formulas, was most highly correlated with Factor II from the old test, Algebraic Operations and Fractions, (r=+.6460). Both involved fractions and algebraic operations. Factor I from the new test was correlated, but to a lesser extent, with Factor IV from the old test, Metric Measurement, (r=+.4102). Since the Metric Measurement Factor from the old test involved computing perimeters and areas which involves formulas, this result was also expected. Factor II from the new test, Decimals, was most highly correlated with Factor I from the old test, Arithmetic, Whole Number and Decimal Multiplication and Division, (r=+.2944) and Factor III from the old test, Ratio, Proportion and Probability, (r=+.2792). Although these correlation coefficients are not high in practical terms, these factors had the highest correlations with Factor II from the new test. All three of these factors involved decimals. Factor III from the new test, Division, was most highly correlated with Factor II from the old test, Algebraic Operations and Fractions, (r=+.3854) and Factor V from the old test, Non-Metric Measurement, (r=+.3096). Factor II from the old test involved some division which would account for this relationship. Factor V from the old test, however, did not. No rationale for this relationship was apparent.

Factor Analysis of Both Versions

The next phase of the data analysis was prompted by the results of the two factor analyses described above. Since the analysis of the new test resulted in three factors and the analysis of the old test resulted in five factors, and since 14 objectives were common to the two tests, all 68 objectives (28 from the new test and 40 from the old test) were factor analyzed together in an effort to determine the relationship among all the objectives on both forms of the test. The initial iterated principal components analysis resulted in nine factors having eigenvalues greater than one which were rotated to simple structure using the varimax procedure. Seven of the nine rotated factors had significant loadings. The rotated factor matrix appears in Appendix C, Table C-4. These seven factors, together with the objectives loading on them, are displayed in Figure 4.

Factor I was identified as Arithmetic Computation. The objectives with the highest loadings on Factor I were: whole number division word problems; multiply fractions; multiply decimals; multiply decimals word problems; order a set of decimals; find the mean of a set of numbers; read a coordinate system; decimal divided by a whole number; word problems--find the percentage of a number; money word problems; probability of a simple event; time conversion;

FIGURE 4

FACTORS RESULTING FROM THE PRINCIPAL COMPONENTS ANALYSIS AND VARIMAX ROTATION OF THE 68 OBJECTIVES ASSESSED ON THE OLD (1979) AND NEW (1980) VERSIONS OF THE GRADE 10 MEAP MATHEMATICS TEST

Factors Number/Name	Objectives Loading On Each Factor
I New Test: Arithmetic Computation	Whole number division word problems
	Multiply fractions
	Multiply decimals
	Multiply decimals word problems
	Order a set of decimals
	Find the mean of a set of numbers
	Read a coordinate system
	Decimal divided by a whole number
	Word problems--find the percentage of a number
	Money word problems
	Probability of a simple event
	Time conversion
	Evaluate common algebraic expressions
	Convert common fractions to decimals
	Convert mixed numbers to common fractions
	Find the larger of two fractions
	Convert fractions, decimals, percents
	Decimal divided by a decimal
	Volume computation
II Old Test: Using Standard Units of Measure to Solve Problems	Read a coordinate system
	Multiply or divide money by a positive integer
	Write a ratio describing an indicated comparison
	Locate items in a table of data
	Order a set of decimals
	Predict the number of times an event will occur
	Convert fractions, decimals, percents
	Multiply fractions

(more)

FIGURE 4--Continued

Factors Number/Name	Objectives Loading On Each Factor
	Identify congruent and non-congruent figures Word problems--find the percentage of a number Write exponents as the product of factors
III Old Test: Word Problems	Decimal times a decimal Answer questions using a bar graph Word problems--standard units of measure Given the cost, what could be purchased Whole number division--computation Find the larger of two fractions Convert common fractions to decimals Determine a percentage of a given number Parts of a circle Find a set of equivalent fractions
IV Old Test: Algebra	Evaluate common algebraic expressions Locate integers on a number line Solve linear equations Find the difference in time intervals Add integers Round decimals to the nearest one, tenth, hundredth Measure an object to the nearest unit Find the mean of a set of numbers Write equivalent ratios by supplying the missing whole number

(more)

FIGURE 4--Continued

Factors Number/Name	Objectives Loading On Each Factor
V Fractions	Add mixed numbers
	Subtract mixed numbers with unlike denominators[b]
	Subtract fractions with unlike denominators[a]
	Subtract mixed numbers with unlike denominators[a]
	Subtract fractions with unlike denominators[b]
	Word problems: addition of fractions
	Add fractions
	Whole number times a mixed number[b]
	Whole number times a mixed number[a]
	Whole number times a fraction
	Decimal times a whole number
VI Geometry	Area word problems
	Word problems: rectangles, triangles, and circles
	Measure a triangle and find the area
	Find the perimeter of polygons and circles
	Parts of a circle
	Angle measurement
VII Divide Decimals	Decimal divided by a decimal

[a]New test objective

[b]Old test objective

evaluate common algebraic expressions; convert mixed mixed number to common fraction; convert common fraction to decimal; find the larger of two fractions; convert fractions, decimals, percents; decimal divided by a decimal; and volume computation. All of these objectives were from the new test.

Factor II was identified as Word Problems Involving Standard Units of Measure. The objectives with the highest loadings on Factor II were: read a coordinate system; multiply or divide money by a positive integer; write a ratio describing an indicated comparison; locate items in a table of data; order a set of decimals; predict the number of times an event will occur; convert fractions, decimals, percents; multiply fractions; identify congruent and non-congruent figures; word problems--find the percentage of a number; and write exponents as the product of factors. All of these objectives were from the old test.

Factor III was identified as Word Problems. The objectives having the highest loadings on Factor III were: decimal times a decimal; answer questions using a bar graph; word problems--standard units of measure; given the cost, what could be purchased; whole number division--computation; find the larger of two fractions; convert common fractions to decimals; determine a percentage of a given number; parts of a circle; and find a set of equivalent fractions. All of these objectives were also from the old test.

Factor IV was identified as Algebra. The objectives having the highest loadings on Factor IV were: evaluate common algebraic expressions; locate integers on a number line; solve linear equations; find the difference in time intervals; add integers; round decimals to the nearest one, tenth, hundredth; measure an object to the nearest unit; find the mean of a set of numbers; and write equivalent ratios by supplying the missing whole number. All of these objectives were also from the old test.

Factor V was identified as Fractions, and had high loadings from both the old and new test objectives. Old test objectives with high loadings were: add mixed numbers; subtract mixed numbers; subtract fractions; whole number times a mixed number; whole number times a fraction; and decimal times a whole number power of ten. New test objectives with high loadings were: subtract fractions; subtract mixed numbers; word problems: addition of fractions; add fractions; and whole number times a mixed number. Three of the 14 pairs of common objectives from the two tests loaded together on this factor.

Factor VI was identified as Geometry, and also had high loadings from both old and new test objectives. The old test objectives with high loadings on Factor VI were: word problems: rectangles, triangles, and circles; measure a triangle and find the area; and find the perimeter of polygons and circles. The new test objectives with high loadings on Factor VI were: area word problems; parts of a circle; and angle measurement. None of the 14 pairs of common objectives loaded together on this factor.

Factor VII was identified as Decimal Division. Only one objective had a high loading on Factor VII: decimal divided by a decimal from the new test.

First Subsequent Analysis: Two Sets of Objectives (No Recoding)

The results of the single factor analysis of all 68 objectives indicated that there was probably a great deal of method variance which had caused the objectives from the old test and the new test to load almost entirely on different factors. The old and new tests shared a set of 14 objectives which consisted of three identical items with a fourth similar item appearing on the old test. The subsequent analyses were undertaken in order to explore this method variance. For each of them, the 14 pairs of common objectives were factor analyzed separately from the remaining 40 objectives (14 from the new test, 26 from the old test) which were not common to the two tests.

The first of the subsequent analyses involved factor analyzing the two sets of objectives (14 pairs of common objectives, 40 remaining objectives) without making any adjustments in the scores on either of the instruments. This was undertaken in an attempt to explore the structures of these two sets of objectives separately and especially to discover how the 14 pairs of common objectives behaved when the remaining 40 were not present. The results of these two analyses appear in Appendix C, Tables C-5 and C-6.

The factor matrix resulting from the iterated principal components analysis followed by varimax rotation of the 14 pairs of common objectives from the old (1979) and new (1980) Grade 10 MEAP mathematics tests appears in Table C-5 in Appendix C. The initial iterated principal components analysis resulted in four factors having eigenvalues greater than one which were rotated to simple structure using the varimax procedure. These four factors, together with the objectives loading on them, are presented in Figure 5.

Factor I was identified as Decimals and Percents (New Test). The objectives with the highest loadings on Factor I were: decimal times a decimal; find the mean of a set of numbers; multiply fractions; order a set of decimals; read a coordinate system; word problems--find percentage of a given number; decimal divided by a decimal; find the larger of two fractions; convert fractions, decimals, percents; parts of a circle (all from

FIGURE 5

FACTORS RESULTING FROM THE PRINCIPAL COMPONENTS ANALYSIS AND VARIMAX ROTATION OF THE 14 PAIRS OF OBJECTIVES COMMON TO THE OLD (1979) AND NEW (1980) VERSIONS OF THE GRADE 10 MEAP MATHEMATICS TEST (NO RECODING)

Factors Number/Name		Objectives Loading On Each Factor
I	Decimals and Percents (New Test)	Decimal times a decimal Find the mean of a set of numbers[a] Multiply fractions Order a set of decimals Read a coordinate system Word problems: find percentage of a number Decimal divided by a decimal Find the larger of two fractions Convert fractions, decimals, percents Find the mean of a set of numbers[b] Parts of a circle
II	Decimals and Percents (Old Test)	Order a set of decimals Convert fractions, decimals, percents Word problems: find percentage of a number Decimal times a decimal Decimal divided by a decimal Parts of a circle Multiply fractions
III	Fractions	Subtract mixed numbers with unlike denominators[b] Subtract mixed numbers with unlike denominators[a] Subtract fractions with unlike denominators[a] Subtract fractions with unlike denominators[b] Whole number times a mixed number[b] Whole number times a mixed number[a]

(more)

FIGURE 5--Continued

Factors Number/Name	Objectives Loading On Each Factor
IV Algebra	Evaluate common algebraic expressions[a]
	Find the larger of two fractions
	Evaluate common algebraic expressions[b]

[a]New test objective

[b]Old test objective

the new test); and find the mean of a set of numbers (from the old test).

Factor II was identified as Decimals and Percents (Old Test). The objectives with the highest loadings on Factor II were: read a coordinate system; order a set of decimals; convert fractions, decimals, percents; word problems--find percentage of a number; decimal times a decimal; decimal divided by a decimal; parts of a circle; and multiply fractions (all from the old test).

Factor III was identified as Fractions. The objectives with high loadings on Factor III were: subtract mixed numbers (both objectives), subtract fractions (both objectives), and whole number times a mixed number (both objectives).

Factor IV was identified as Algebra. The objectives with high loadings on Factor IV were: evaluate common algebraic expressions (both objectives), and find the larger of two fractions (from the old test).

The factor matrix resulting from the iterated principal components analysis followed by varimax rotation of the 40 objectives not common to the old (1979) and new (1980) Grade 10 MEAP mathematics tests appears in Table C-6 in Appendix C. The initial iterated principal components analysis resulted in six factors with eigenvalues greater than one which were rotated to simple structure using the varimax procedure. Only five had significant loadings following rotation. These five factors, together with the objectives loading on them, are presented in Figure 6.

Factor I was identified as Word Problems. The objectives with the highest loadings on Factor I were: Whole number division--word problems; whole number division--computation; multiplication of decimals--word problems; decimal divided by a whole number; time conversion; money--word problems; convert mixed number to common fraction; probability of a simple event; and volume computation (all from the new test).

Factor II was identified as Algebra. The objectives with the highest loadings on Factor II were: locate integers on a number line; find the difference in time intervals; add integers; round to the nearest one, tenth, or hundredth; solve linear equations; measure an object to

FIGURE 6

FACTORS RESULTING FROM THE PRINCIPAL COMPONENTS ANALYSIS AND VARIMAX ROTATION OF THE 40 OBJECTIVES NOT COMMON TO THE OLD (1979) AND NEW (1980) VERSIONS OF THE GRADE 10 MEAP MATHEMATICS TEST (NO RECODING)

Factors Number/Name		Objectives Loading On Each Factor
I	Word Problems	Whole number division--word problems
		Whole number division--computation
		Multiplication of decimals--word problems
		Decimal divided by a whole number
		Time conversion
		Money word problems
		Convert mixed numbers to common fractions
		Probability of a simple event
		Volume computation
II	Algebra	Locate integers on a number line
		Find difference in time intervals
		Add integers
		Round to the nearest one, tenth, hundredth
		Solve linear equations
		Measure object to nearest unit
		Convert fractions to decimals
		Add mixed numbers
		Whole number times a fraction
		Write exponents as the product of factors
III	Using Standard Units of Measure	Area word problems
		Measure a triangle and find area
		Word problems--rectangles, triangles, circles
		Angle measurement
		Addition of fractions--word problems
		Add fractions with unlike denominators
		Write equivalent ratios by supplying the missing whole number

(more)

FIGURE 6--Continued

Factors Number/Name	Objectives Loading On Each Factor
IV Non-Metric Measurement	Multiply or divide money by a positive integer Write a ratio describing an indicated comparison Locate items in a table of data Predict the number of times an event will occur Identify congruent and non-congruent figures Decimal times a whole number power of ten
V Using Charts and Graphs	Answer questions using a bar graph Given the cost, what could be purchased Whole number division--computation Convert common fractions to decimals Word problems--standard units of measure Determine percentage of a given number Find a set of equivalent fractions

the nearest unit; add mixed numbers; whole number times a fraction; write exponents as the product of factors (from the old test); and convert fractions to decimals (from the new test).

Factor III was identified as Using Standard Units of Measure. The objectives with the highest loadings on Factor III were: area word problems; angle measurement; addition of fractions--word problems; add fractions (from the new test); measure a triangle and find the area; word problems--rectangles, triangles, circles; find the perimeter of polygons and circles; and write equivalent ratios by supplying the missing whole number (from the old test).

Factor IV was identified as Non-Metric Measurement. The objectives with the highest loadings on Factor IV were: multiply or divide money by a positive integer; write a ratio describing an indicated comparison; locate items in a table of data; predict the number of times an event will occur; identify congruent and non-congruent figures; and multiply a decimal by a whole number power of ten (all from the old test).

Factor V was identified as Using Charts and Graphs. The objectives with the highest loadings on Factor V were: answer questions using a bar graph; given the cost, what could be purchased; whole number division--computation; convert common fractions to decimals; word problems--standard units of measure; determine percentage of a given number; and find a set of equivalent fractions (all from the old test).

Factor scores were computed for each of the 557 students based upon the four factors extracted from the 14 pairs of common objectives and the six factors extracted from the 40 objectives not common to the two tests. Pearson product-moment correlation coefficients were computed on all pairs of sets of factor scores. The resulting correlation matrix appears in Appendix C, Table C-7. A summary of the intercorrelations among the factor scores is presented in Figure 7.

FIGURE 7

SUMMARY OF THE INTERCORRELATIONS AMONG FACTOR SCORES FOR THE 14 PAIRS OF COMMON OBJECTIVES AND THE 40 OBJECTIVES NOT COMMON TO THE OLD (1979) AND NEW (1980) VERSIONS OF THE GRADE 10 MEAP MATHEMATICS TEST

14 Pairs Of Common Objectives	40 Objectives Not Common Factor I	Factor II	Factor III	Factor IV	Factor V	Factor VI
Factor I	0.7527*	0.1999	0.2439	0.0636	0.0160	0.0539
Factor II	0.0463	0.1937	0.1606	0.7483*	0.4245	0.0238
Factor III	0.2825	0.4139*	0.3624*	0.0414	0.1664	0.4471*
Factor IV	0.1373	0.3340	0.4146*	0.0093	0.4855*	0.0051

*Asterisks indicate the highest intercorrelations among factor scores.

The results of this correlational analysis indicated that Factor I from the 14 pairs of common objectives, Decimals and Percents (New Test), was most highly correlated with Factor I from the 40 objectives not common to the two tests, Word Problems, (r=+.7527). Both of these were new test factors.

Factor II from the 14 pairs of common objectives, Decimals and Percents (Old Test), was most highly correlated with Factor IV from the 40 objectives not common to the two tests, Non-Metric Measurement, (r=+.7483). Both of these were old test factors.

Factor III from the 14 pairs of common objectives, Fractions, was highly correlated with Factors II, Algebra, VI, and III, Using Standard Units of Measure, from the 40 objectives not common to the two tests (r=+.4139, +.4471, and +.3624, respectively). Factor III from the 14 pairs of common objectives was defined by both old and new test objectives as was Factor II from the 40 objectives. Factor VI from the 40 objectives had no significant loadings while Factor III from that set was an old test factor.

Factor IV from the 14 pairs of common objectives, Algebra, was most highly correlated with Factors V, Using Charts and Graphs, and III, Using Standard Units of Measure, from the 40 objectives not common to the two tests (r=+.4855 and +.4146, respectively). Factor IV from the 14 pairs of common objectives was an old and new test factor as was Factor III from the 40 objectives not common to the two tests. Factor V from the 40 objectives was an old test factor.

Second Subsequent Analysis: Two Sets of Objectives (Recode Old Test)

The second subsequent analysis also involved factor analyzing two sets of objectives (14 pairs of common objectives, 40 remaining objectives not common to the two tests). This analysis involved rescaling the scores on the old test in order to equalize the range of scores on the two instruments. It was hoped that this rescaling procedure might remove the method variance which persisted in the analyses described above. It was hypothesized that this method variance might have resulted from the greater variance in the objective scores on the old version of the MEAP test: zero through four, as opposed to zero through three on the new version.

The rescaling procedure used in this analysis involved subtracting one from each non-zero objective score on the old test. Zero scores on the old test remained unchanged, ones became zeros, twos became ones, threes became twos and fours became threes. The new test objective scores remained unchanged. Subtracting one from each of the old version objective scores reduced the range of objective scores on the old version to the same limits as the range of the objective scores on the new version of the test. The results of these two analyses appear in Appendix C, Tables C-8 and C-9.

The factor matrix resulting from the iterated principal components analysis followed by varimax rotation of the 14 pairs of common objectives from the old (1979) and new (1980) Grade 10 MEAP mathematics tests appears in Appendix C, Table C-8. The initial iterated principal components analysis resulted in five factors having eigenvalues greater than one which were rotated to simple structure using the varimax procedure. These five factors, together with the objectives loading on them, are presented in Figure 8.

Factor I was identified as Decimals and Percents (New Test). The objectives with the highest loadings on Factor I were: multiply fractions; decimal times a decimal; order a set of decimals; find the mean of a set of numbers; read a coordinate system; word problems--find percentage of a number; find the larger of two fractions; and convert fractions, decimals, percents (all from the new test).

Factor II was identified as Subtraction of Fractions. The objectives with the highest loadings on Factor II were three pairs of objectives from the two tests: subtract fractions; subtract mixed numbers; and whole number times a mixed number. These three pairs accounted for six objectives.

Factor III was identified as Decimals and Percents (Old Test). The objectives with the highest loadings on Factor III were: order a set of decimals; read a coordinate system; convert fractions, decimals, percents; word problems--find percentage of a given number; decimal times a decimal; and multiply fractions (all from the old test).

FIGURE 8

FACTORS RESULTING FROM THE PRINCIPAL COMPONENTS ANALYSIS AND VARIMAX ROTATION OF THE 14 PAIRS OF OBJECTIVES COMMON TO THE OLD (1979) AND NEW (1980) VERSIONS OF THE GRADE 10 MEAP MATHEMATICS TEST (OLD TEST SCORES RECODED*--NEW TEST SCORES UNCHANGED)

Factors Number/Name		Objectives Loading On Each Factor
I	Decimals and Percents (New Test)	Multiply fractions
		Decimal times a decimal
		Order a set of decimals
		Find the mean of a set of numbers
		Read a coordinate system
		Word problems--find percentage of a given number
		Find the larger of two fractions
		Convert fractions, decimals, percents
II	Subtraction of Fractions	Subtract fractions with unlike denominators[a]
		Subtract mixed numbers with unlike denominators[a]
		Subtract mixed numbers with unlike denominators[b]
		Subtract fractions with unlike denominators[b]
		Whole number times a mixed number[b]
		Whole number times a mixed number[a]
III	Decimals and Percents (Old Test)	Order a set of decimals
		Read a coordinate system
		Convert fractions, decimals, percents
		Word problems--find percentage of a given number
		Decimal times a decimal
		Multiply fractions
IV	Algebra	Evaluate common algebraic expressions[a]
		Evaluate common algebraic expressions[b]

(more)

FIGURE 8--Continued

Factors Number/Name	Objectives Loading On Each Factor
	Find the larger of two fractions
	Parts of a circle[b]
	Parts of a circle[a]
V Division	Decimal divided by a decimal[b]
	Decimal divided by a decimal[a]
	Find the mean of a set of numbers

*Old test scores were recoded as follows:
0=0 1=0 2=1 3=2 4=3.

[a]New test objective

[b]Old test objective

Factor IV was identified as Algebra. The objectives with the highest loadings on Factor IV were two pairs of common objectives from the old and new tests: evaluate common algebraic expressions and parts of a circle (four objectives), and one additional objective from the old test: find the larger of two fractions.

Factor V was identified as Division. The objectives with the highest loadings on Factor V were one pair of common objectives from the old and new tests: decimal divided by a decimal (two objectives), and one additional objective from the old test: find the mean of a set of numbers.

The factor matrix resulting from the iterative principal components analysis followed by varimax rotation of the 40 objectives not common to the old (1979) and new (1980) Grade 10 MEAP mathematics tests appears in Table C-9 in Appendix C. The initial iterated principal components analysis resulted in six factors with eigenvalues greater than one which were rotated to simple structure using the varimax procedure. Only five factors had significant loadings following rotation. These five factors, together with the objectives loading on them, are presented in Figure 9.

Factor I was identified as Geometric Measurement. The objectives with the highest loadings on Factor I were: word problems--rectangles, triangles and circles; measure a triangle and find area; convert common fractions to decimals; word problems--standard units of measure; find the perimeter of polygons and circles; determine percentage of a given number; write equivalent ratio--supply missing whole number; find a set of equivalent fractions (from the old test); area word problems; angle measurement; and addition of fractions (from the new test).

Factor II was identified as Division. The objectives with the highest loadings on Factor II were: whole number division--word problems; whole number division--computation; word problems--decimal multiplication; decimal divided by a whole number; convert mixed numbers to improper fractions; probability of a simple event; time conversion; money word problems; and volume computation (all from the new test).

FIGURE 9

FACTORS RESULTING FROM THE PRINCIPAL COMPONENTS ANALYSIS AND VARIMAX ROTATION OF THE 40 OBJECTIVES NOT COMMON TO THE OLD (1979) AND NEW (1980) VERSIONS OF THE GRADE 10 MEAP MATHEMATICS TEST (OLD TEST SCORES RECODED*-NEW TEST SCORES UNCHANGED)

Factors Number/Name	Objectives Loading On Each Factor
I Geometric Measurement	Word problems--rectangles, triangles and circles
	Measure triangle and find area
	Convert common fractions to decimals
	Word problems--standard units of measure
	Area word problems
	Find perimeter of polygons and circles
	Determine percentage of a given number
	Write equivalent ratios by supplying the missing whole number
	Find a set of equivalent fractions
	Angle measurement
	Add fractions with unlike denominators
II Division	Whole number division--word problems
	Whole number division--computation
	Word problems--decimal multiplication
	Decimal divided by a whole number
	Convert mixed numbers to improper fractions
	Probability of a simple event
	Time conversion
	Money word problems
	Volume computation

(more)

FIGURE 9--Continued

Factors Number/Name		Objectives Loading On Each Factor
III	Using Charts and Graphs	Locate items in a table of data Given cost, what could be purchased Multiply or divide money by a positive integer Whole number division--computation Write a ratio describing an indicated comparison Answer questions using a bar graph Predict the number of times an event will occur Decimal times a whole number power of ten Write an exponent as a set of factors
IV	Algebra	Locate integers on a number line Find the difference in time intervals Solve linear equations Add integers Convert fractions to decimals Round to the nearest one, tenth, hundredth Add mixed numbers Measure objects to the nearest unit Whole number times a fraction Identify congruent and non-congruent figures
V	Addition of Fractions Word Problems	Word problems--addition of fractions

*Old test scores were recoded as follows:
0=0 1=0 2=1 3=2 4=3.

Factor III was identified as Using Charts and Graphs. The objectives with the highest loadings on Factor III were: locate items in a table of data; given cost, what could be purchased; multiply or divide money by a positive integer; whole number division--computation; write a ratio describing an indicated comparison; answer questions using a bar graph; predict the number of times an event will occur; decimal times a whole number power of ten; and write an exponent as a set of factors (all from the old test).

Factor IV was identified as Algebra. The objectives with the highest loadings on Factor IV were: locate integers on a number line; find the difference in time intervals; solve linear equations; add integers; round to the nearest one, tenth, hundredth; add mixed numbers; measure objects to the nearest unit; whole number times a fraction; identify congruent and non-congruent figures (from the old test); and convert fractions to decimals (from the new test).

Factor V was identified as Addition of Fractions Word Problems. Only one objective had its highest loading on Factor V: word problems--addition of fractions (from the new test).

Factor scores were computed for each of the 557 students based upon the five factors extracted from the 14 pairs of common objectives and the six factors extracted from the 40 objectives not common to the two tests following recoding* of the old test scores. Pearson product-moment correlation coefficients were computed on all pairs of sets of factor scores. The resulting correlation matrix appears in Appendix C, Table C-10. A summary of the intercorrelations among the factor scores is presented in Figure 10.

The results of this correlational analysis indicated that Factor I from the 14 pairs of common objectives, Decimals and Percents (New Test), was most highly correlated with Factor II from the 40 objectives not common to the two tests, Division, (r=+.7679). Both of these were new test factors.

Factor II from the 14 pairs of common objectives, Subtraction of Fractions, was most highly correlated with Factor V from the 40 objectives not common to the two tests, Addition of Fractions Word Problems, (r=+.3955). Factor II from the 14 pairs of common objectives was defined by old and new test objectives loaded in pairs while Factor V from the 40 objectives not common to the two tests was defined by old test objectives.

Factor III from the 14 pairs of common objectives, Decimals and Percents (Old Test), was most highly correlated with Factor III from the 40 objectives not common to the two tests, Using Charts and Graphs, (r=+.6978). Both

*Old test scores were recoded as follows:
0=0 1=0 2=1 3=2 4=3.

were old test factors.

Factor IV from the 14 pairs of common objectives, Algebra, was most highly correlated with Factor I from the 40 objectives not common to the two tests, Geometric Measurement, (r=+.5649). Factor IV from the 14 pairs of common objectives was defined by old and new objectives loaded in pairs while Factor I from the 40 objectives not common to the two tests was defined by old test objectives. Factor IV from the 14 pairs of common objectives, Algebra, was also highly correlated with Factor IV from the 40 objectives not common to the two tests, Algebra, (r=+.4019).

FIGURE 10

SUMMARY OF THE INTERCORRELATIONS AMONG FACTOR SCORES FOR THE 14 PAIRS OF COMMON OBJECTIVES AND THE 40 OBJECTIVES NOT COMMON TO THE OLD[a] (1979) AND NEW (1980) VERSIONS OF THE GRADE 10 MEAP MATHEMATICS TEST

14 Pairs Of Common Objectives	40 Objectives Not Common				
	Factor I	Factor II	Factor III	Factor IV	Factor V
Factor I	0.0892	0.7679*	0.0801	0.1277	0.0598
Factor II	0.2774	0.2699	0.1020	0.3688	0.3955*
Factor III	0.2863	0.0619	0.6978*	0.2147	0.0289
Factor IV	0.5649*	0.1948	0.1208	0.4019*	-0.0275
Factor V	0.3096*	0.1901	0.1807	0.2610	0.2226

[a]Old test scores were recoded as follows:
0=0 1=0 2=1 3=2 4=3.

*Asterisks indicate highest intercorrelations among factor scores.

Factor V from the 14 pairs of common objectives, Division, was most highly correlated with Factor I from the 40 objectives not common to the two tests, Geometric Measurement, ($r=+.3096$). Factor V from the 14 pairs of common objectives was defined by one pair of old and new objectives and an additional old objective while Factor I from the 40 objectives not common to the tests was defined by old test objectives.

The transformation of each of the old test objective scores was undertaken in order to equalize the variance in the distributions of the old and new test scores. In order to investigate the effectiveness of this transformation, means were computed for each of the 28 objectives (14 old test, 14 new test) in the set of 14 pairs of common objectives. Each pair of objective score means was tested for equivalence using a correlated t-test (t-test for dependent groups) since the same individuals took both tests. The results of these analyses appear in Table 2. Only two pairs of objectives had mean scores which were not significantly different ($\alpha=.05$): read a coordinate system and whole number times a mixed number. In addition, the differences were in favor of the new test, which was administered first, for thirteen of the fourteen objectives. The only exception was multiplying fractions.

These results indicated that the transformation used to recode the old test objective scores may have

TABLE 2

CORRELATED t-TESTS ON OLD[a] AND NEW TEST SCORES ON 14 PAIRS OF COMMON OBJECTIVES

Objectives	Old Test Mean (Std. Dev.)	New Test Mean (Std. Dev.)	t	df	Significance
Order a set of decimals	1.7181 (1.074)	2.0485 (1.144)	+6.44	556	**
Decimal X decimal	1.6535 (1.288)	2.2154 (1.025)	+10.46	556	**
Decimal divided by decimal	1.1849 (1.122)	1.3591 (1.025)	+3.63	556	**
Find the larger of two fractions	1.5099 (1.272)	1.8941 (1.237)	+7.63	556	**
Multiply fractions	2.5943 (0.818)	2.3591 (1.066)	-4.92	556	**
Convert fractions, decimals, percents	1.6355 (1.094)	1.8977 (0.972)	+5.33	556	**
Word problems--find percentage of a number . . .	1.6445 (1.158)	1.8977 (1.089)	+5.24	556	**
Find the mean of a set of numbers	1.8115 (1.202)	1.9713 (1.109)	+3.30	556	**
Evaluate common algebraic expressions	1.6427 (1.275)	1.7379 (1.189)	+2.31	556	*

(more)

TABLE 2--Continued

Objectives	Old Test Mean (Std. Dev.)	New Test Mean (Std. Dev.)	t	df	Significance
Read a coordinate system	2.5925 (0.884)	2.6248 (0.794)	+0.78	556	NS
Subtract fractions	1.6661 (1.387)	1.9336 (1.284)	+5.40	556	**
Subtract mixed numbers	1.4111 (1.309)	1.5242 (1.269)	+2.38	556	*
Whole number X mixed number	0.9156 (1.294)	1.0000 (1.278)	+1.60	556	NS
Parts of a circle	1.4039 (1.180)	1.6822 (1.118)	+5.37	556	**

[a]Old test scores were recoded as follows: 0=0 1=0 2=1 3=2 4=3.

NS = not significant

* = $p < .05$

** = $p < .01$

introduced a systematic bias into the scores.

Third Subsequent Analysis: Two Sets of Objectives (Recode Old Test)

The third subsequent analysis, like the second, involved factor analyzing two sets of objectives (14 pairs of common objectives, 40 objectives not common to the two tests). This analysis also involved rescaling the scores on the old test in order to equalize the range of scores on the two instruments. The previous rescaling had produced mean scores on 13 of the 14 pairs of common objectives which were lower on the new test than on the old test. Since three of the items on the two tests were identical, practice effect should have resulted in higher scores on these objectives when they were presented the second time. The opposite result indicated that the rescaling procedure may have introduced systematic bias into the old test objective scores. It was hoped that this rescaling would remove the method variance while resulting in less bias than in the previous analysis.

The rescaling used in this analysis involved the following procedure. For the old test, objective scores of zero and three remained unchanged. Scores of one or two were recoded to a value of 1.5. Scores of four were recoded to a value of three. The new test objective scores remained unchanged. This rescaling procedure reduced the range of the objective scores on the old test from five values to four (the same as the range of the new test objective scores) and also tended to normalize the distribution of objective scores on the old test by recoding both ones and twos to the value of 1.5 forcing more scores into the mean value of the two extreme scores. The results of these two analyses appear in Appendix C, Tables C-11 and C-12.

The factor matrix resulting from the iterated principal components analysis followed by varimax rotation of the 14 pairs of common objectives from the old (1979) and new (1980) Grade 10 MEAP mathematics tests appears in Appendix C, Table C-11. The initial iterated principal components analysis resulted in four factors having eigenvalues greater than one which were rotated to simple structure using the varimax procedure. These four factors, together with the objectives loading on them, are presented in Figure 11.

Factor I was identified as Decimals (New Test). The objectives with the highest loadings on Factor I were: find the mean of a set of numbers (both the new and old test objectives); decimal times a decimal; order a set of decimals; multiply fractions; evaluate common algebraic expressions; word problems--find percentage of a number; read a coordinate system; find the larger of two fractions; decimal divided by a decimal; convert

FIGURE 11

FACTORS RESULTING FROM THE PRINCIPAL COMPONENTS ANALYSIS AND VARIMAX ROTATION OF THE 14 PAIRS OF OBJECTIVES COMMON TO THE OLD (1979) AND NEW (1980) VERSIONS OF THE GRADE 10 MEAP MATHEMATICS TEST (OLD TEST SCORES RECODED*-NEW TEST SCORES UNCHANGED)

Factors Number/Name	Objectives Loading On Each Factor
I Decimals (New Test)	Find the mean of a set of numbers[a]
	Decimal times a decimal
	Order a set of decimals
	Multiply fractions
	Evaluate common algebraic expressions
	Word problems--find percentage of a given number
	Read a coordinate system
	Find the larger of two fractions
	Decimal divided by a decimal
	Convert fractions, decimals, percents
	Parts of a circle
	Find the mean of a set of numbers[b]
II Decimals (Old Test)	Read a coordinate system
	Convert fractions, decimals, percents
	Order a set of decimals
	Word problems--find percentage of a given number
	Decimal divided by a decimal
	Multiply fractions
III Fractions	Subtract mixed numbers with unlike denominators[b]
	Subtract fractions with unlike denominators[a]
	Subtract mixed numbers with unlike denominators[a]
	Subtract fractions with unlike denominators[b]

(more)

FIGURE 11--Continued

Factors Number/Name	Objectives Loading On Each Factor
	Whole number times a mixed number[b]
	Whole number times a mixed number[a]
	Evaluate common algebraic expressions
IV Comparing Fractions	Find the larger of two fractions
	Parts of a circle
	Decimal times a decimal

*Old test scores were recoded as follows: 0=0 1=1.5 2=1.5 3=3 4=3.

[a]New test objective

[b]Old test objective

fractions, decimals, percents; and parts of a circle (all from the new test).

Factor II was identified as Decimals (Old Test). The objectives with the highest loadings on Factor II were: read a coordinate system; convert fractions, decimals, percents; order a set of decimals; word problems--find percentage of a number; decimal divided by a decimal; and multiply fractions (all from the old test).

Factor III was identified as Fractions. The objectives with the highest loadings on Factor III were three pairs of objectives from the two tests: subtract mixed numbers; subtract fractions; whole number times a mixed number (six objectives); and evaluate common algebraic expressions (from the old test).

Factor IV was identified as Comparing Fractions. The objectives with the highest loadings on Factor IV were: find the larger of two fractions; parts of a circle; and decimal times a decimal (all from the old test).

The factor matrix resulting from the iterated principal components analysis followed by varimax rotation of the 40 objectives not common to the old (1979) and new (1980) Grade 10 MEAP mathematics tests appears in Appendix C, Table C-12. The initial iterated principal components analysis resulted in six factors with eigenvalues greater than one which were rotated to simple structure using the varimax procedure. These six factors, together with the objectives loading on them, are presented in Figure 12.

Factor I was identified as Division. The objectives with the highest loadings on Factor I were: whole number division--word problems; whole number division--computation; multiplication of decimals--word problems; decimal divided by a whole number; time conversion; money word problems; convert mixed numbers to common fractions; probability of a simple event; convert fractions to decimals; and volume computation (all from the new test).

Factor II was identified as Using Charts and Graphs.

FIGURE 12

FACTORS RESULTING FROM THE PRINCIPAL COMPONENTS ANALYSIS AND VARIMAX ROTATION OF THE 40 OBJECTIVES NOT COMMON TO THE OLD (1979) AND NEW (1980) VERSIONS OF THE GRADE 10 MEAP MATHEMATICS TEST (OLD TEST SCORES RECODED*-NEW TEST SCORES UNCHANGED)

Factors Number/Name	Objectives Loading On Each Factor
I Division	Whole number division--word problems
	Whole number division--computation
	Multiplication of decimals--word problems
	Decimal divided by a whole number
	Time conversion
	Money word problems
	Convert mixed numbers to common fractions
	Probability of a simple event
	Convert fractions to decimals
	Volume computation
II Using Charts and Graphs	Given cost, what could be purchased
	Answer questions using a bar graph
	Whole number division--computation
	Word problems--standard units of measure
	Convert common fractions to decimals
	Determine percentage of a given number
	Word problems--rectangles, triangles, circles
	Find a set of equivalent fractions
III Geometry	Area word problems
	Measure a triangle and find area
	Addition of fractions--word problems

(more)

FIGURE 12--Continued

Factors Number/Name	Objectives Loading On Each Factor
	Angle measurement Add fractions with unlike denominators Find the perimeter of polygons and circles Write equivalent ratios by supplying the missing whole number
IV Using Ratios	Multiply or divide money by a positive integer Write a ratio describing an indicated comparison Locate items in a table of data Predict the number of times an event will occur Identify congruent and non-congruent figures Write an exponent as the product of factors
V Algebra	Find the difference in time intervals Round to the nearest one, tenth, hundredth Locate integers on a number line Measure an object to the nearest unit Add integers Solve linear equations
VI Fractions	Add mixed numbers Whole number times a fraction Decimal times a whole number power of ten

*Old test scores were recoded as follows:
0=0 1=1.5 2=1.5 3=3 4=3.

The objectives with the highest loadings on Factor II were: given cost, what could be purchased; answer questions using a bar graph; whole number division--

computation; word problems--standard units of measure; convert common fractions to decimals; determine percentage of a given number; word problems--rectangles, triangles, circles; and find a set of equivalent fractions (all from the old test).

Factor III was identified as Geometry. The objectives with the highest loadings on Factor III were: area word problems; addition of fractions--word problems; angle measurement; add fractions with unlike denominators (from the new test); measure a triangle and find area; find the perimeter of polygons and circles; and write equivalent ratios by supplying the missing whole number (from the old test).

Factor IV was identified as Using Ratios. The objectives with the highest loadings on Factor IV were: multiply or divide money by a positive integer; write a ratio describing an indicated comparison; locate items in a table of data; predict the number of times an event will occur; identify congruent and non-congruent figures; and write an exponent as the product of factors (all from the old test).

Factor V was identified as Algebra. The objectives with the highest loadings on Factor V were: find the difference in time intervals; round to the nearest one, tenth, hundredth; locate integers on a number line; measure an object to the nearest unit; add integers; and solve linear equations (all from the old test).

Factor VI was identified as Fractions. The objectives with the highest loadings on Factor VI were: add mixed numbers; whole number times a fraction; and decimal times a whole number power of ten (all from the old test).

Factor scores were computed for each of the 557 students based upon the four factors extracted from the 14 pairs of common objectives and the five factors extracted from the 40 objectives not common to the two tests following recoding* of the old test scores. Pearson product-moment correlation coefficients were computed on all pairs of sets of factor scores. The resulting correlation matrix appears in Appendix C, Table C-13. A summary of the intercorrelations among the factor scores is presented in Figure 13.

The results of this correlational analysis indicated that Factor I from the 14 pairs of common objectives, Decimals (New Test), was most highly correlated with Factor I from the 40 objectives not common to the two tests, Division, (r=+.7370). Both were new test factors.

Factor II from the 14 pairs of common objectives, Decimals (Old Test), was most highly correlated with Factor IV from the 40 objectives not common to the two

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*Old test scores were recoded as follows:
0=0 1=1.5 2=1.5 3=3 4=3.

tests, Using Ratios, (r=+.7616). Both were old test factors.

FIGURE 13

SUMMARY OF THE INTERCORRELATIONS AMONG FACTOR SCORES FOR THE 14 PAIRS OF COMMON OBJECTIVES AND THE 40 OBJECTIVES NOT COMMON TO THE OLD[a] (1979) AND NEW (1980) VERSIONS OF THE GRADE 10 MEAP MATHEMATICS TEST

14 Pairs Of Common Objectives	40 Objectives Not Common					
	Factor I	Factor II	Factor III	Factor IV	Factor V	Factor VI
Factor I	0.7370*	0.0471	0.3405	0.0269	0.2189	0.1120
Factor II	0.0336	0.4364	0.0881	0.7616*	0.1853	0.0746
Factor III	0.3051	0.1637	0.4210*	-0.0115	0.3134*	0.5419*
Factor IV	0.0912	0.6206*	0.2515	0.0360	0.1540	0.0720

[a]Old test scores were recoded as follows:
0=0 1=1.5 2=1.5 3=3 4=3.

*Asterisks indicate highest intercorrelations among factor scores.

Factor III from the 14 pairs of common objectives, Fractions, was correlated with Factors VI, III, and V from the 40 objectives not common to the two tests, Fractions, Geometry, and Algebra, (r=+.5419, +.4210, and +.3134, respectively). Factor III from the 14 common objectives was defined by three pairs of old and new objectives along with an additional old test objective. Factors VI and V from the 40 objectives not common to both tests were old test factors while Factor III from the same set was defined by both old and new objectives.

Factor IV from the 14 pairs of common objectives, Comparing Fractions, was most highly correlated with Factor II from the 40 objectives not common to the two tests, Using Charts and Graphs, (r=+.6206). Both were old test factors.

The transformation of each of the old test objective scores was undertaken in order to equalize the variance without creating the apparent bias observed in the previous analysis. In order to investigate the effectiveness of this second transformation, means were computed for each of the 28 objectives (14 old test, 14 new test) in the set of 14 pairs of common objectives. Each pair of objective score means was tested for equivalence using a correlated t-test (t-test for dependent groups) since the same individuals took both tests. The results of these analyses appear in Table 3. Only one pair of objectives was not significantly different (α=.05): subtract fractions. However, in all but one case, the old test objective score was higher than the new test score. The exception was decimal times a decimal. This result is more in line with the expected result of practice effect since students had seen three of the four items on the old test when they took the new test three weeks earlier.

TABLE 3

CORRELATED t-TESTS ON OLD[a] AND NEW TEST SCORES ON 14 PAIRS OF COMMON OBJECTIVES

Objectives	Old Test Mean (Std. Dev.)	New Test Mean (Std. Dev.)	t	df	Significance
Order a set of decimals	2.2864 (1.024)	2.0485 (1.144)	−4.76	556	**
Decimal X decimal	2.0467 (1.199)	2.2154 (1.025)	+3.20	556	**
Decimal divided by decimal	1.8070 (1.008)	1.3591 (1.025)	−9.12	556	**
Find the larger of two fractions	2.0278 (1.164)	1.8941 (1.237)	−2.54	556	*
Multiply fractions	2.8142 (0.650)	2.3591 (1.066)	−9.87	556	**
Convert fractions, decimals, percents	2.2163 (1.008)	1.8977 (0.972)	−6.78	556	**
Word problems--find percentage of a number . . .	2.1786 (1.037)	1.8977 (1.089)	−5.91	556	**
Find the mean of a set of numbers	2.3402 (0.925)	1.9713 (1.109)	−8.38	556	**
Evaluate common algebraic expressions	2.1221 (1.104)	1.7379 (1.189)	−9.35	556	**

(more)

TABLE 3--Continued

Objectives	Old Test Mean (Std. Dev.)	New Test Mean (Std. Dev.)	t	df	Significance
Read a coordinate system	2.7415 (0.772)	2.6248 (0.794)	- 2.90	556	**
Subtract fractions	1.9794 (1.268)	1.9336 (1.284)	- 0.94	556	NS
Subtract mixed numbers	1.8501 (1.220)	1.5242 (1.269)	- 7.04	556	**
Whole number X mixed number	1.2065 (1.340)	1.0000 (1.278)	- 3.77	556	**
Parts of a circle	1.9632 (1.125)	1.6822 (1.118)	- 5.24	556	**

[a]Old test scores were recoded as follows: 0=0 1=1.5 2=1.5 3=3 4=3.

NS = not significant

* = $p < .05$

** = $p < .01$

The results indicated that bias may still have been present since the scores were significantly different in all but one case. The bias, however, was now in the opposite direction.

Fourth Subsequent Analysis: Two Sets of Objectives (Recode Both Tests)

The fourth subsequent analysis, like the second and third, involved factor analyzing two sets of objectives (14 pairs of common objectives, 40 objectives not common to the two tests). This analysis involved rescaling the scores on both the old and new tests in order to equalize the range of scores on the two tests and to attempt to remove the bias which was observed in previous rescaling attempts. This final rescaling procedure was attempted because the rescaling described above resulted in no improvement in the observed differences on the 14 pairs of common objectives nor in the interpretability of the resulting factors.

The rescaling used in this analysis involved the following procedures. For the old test, objective scores of zero and three remained unchanged. Scores of one or two were recoded to a value of 1.5. Scores of four were recoded to a value of three. The new test objective scores were recoded in a similar fashion. Scores of zero and three remained unchanged. Scores of one and two were recoded to a value of 1.5. The results of these two analyses appear in Appendix C, Tables C-14 and C-15. Rescaling both tests in a similar fashion was intended to equalize any bias introduced into the objective scores by the rescaling procedure.

The factor matrix resulting from the iterated principal components analysis followed by varimax rotation of the 14 pairs of common objectives from the old (1979) and new (1980) Grade 10 MEAP mathematics tests appears in Appendix C, Table C-14. The initial iterated principal components analysis resulted in five factors having eigenvalues greater than one which were rotated to simple structure using the varimax procedure. These five factors, together with the objectives loading on them, are presented in Figure 14.

Factor I was identified as Fractions and Decimals (New Test). The objectives with the highest loading on Factor I were: find the mean of a set of numbers (both the new and old test objectives); decimal times a decimal; word problems--find percentage of a number; order a set of decimals; multiply fractions; evaluate common algebraic expressions; decimal divided by a decimal; read a coordinate system; find the larger of two fractions; parts of a circle; and convert fractions, decimals, percents (all from the new test).

FIGURE 14

FACTORS RESULTING FROM THE PRINCIPAL COMPONENTS ANALYSIS AND VARIMAX ROTATION OF THE 14 PAIRS OF OBJECTIVES COMMON TO THE OLD (1979) AND NEW (1980) VERSIONS OF THE GRADE 10 MEAP MATHEMATICS TEST (OLD AND NEW TEST SCORES RECODED*)

Factors Number/Name		Objectives Loading On Each Factor
I	Fractions and Decimals (New Test)	Find the mean of a set of numbers[a]
		Decimal times a decimal
		Word problems--find percentage of a number
		Order a set of decimals
		Multiply fractions
		Evaluate common algebraic expressions
		Decimal divided by a decimal
		Read a coordinate system
		Find the larger of two fractions
		Parts of a circle
		Convert fractions, decimals, percents
		Find the mean of a set of numbers[b]
II	Fractions and Decimals (Old Test)	Read a coordinate system
		Order a set of decimals
		Convert fractions, decimals, percents
		Word problems--find percentage of a number
		Decimal divided by a decimal
		Multiply fractions
III	Subtraction of Fractions	Subtract mixed numbers with unlike denominators[b]
		Subtract mixed numbers with unlike denominators[a]
		Subtract fractions with unlike denominators[a]
		Subtract fractions with unlike denominators[b]
		Evaluate common algebraic expressions

(more)

FIGURE 14--Continued

Factors Number/Name		Objectives Loading On Each Factor
IV	Comparing Fractions	Find the larger of two fractions Decimal times a decimal Parts of a circle
V	Multiplying Whole and Mixed Numbers	Whole number times a mixed number[a] Whole number times a mixed number[b]

*Old test scores were recoded as follows:
0=0 1=1.5 2=1.5 3=3 4=3.

New test scores were recoded as follows:
0=0 1=1.5 2=1.5 3=3.

[a]New test objective

[b]Old test objective

Factor II was identified as Fractions and Decimals (Old Test). The objectives with the highest loadings on Factor II were: read a coordinate system; order a set of decimals; convert fractions, decimals, percents; word problems--find percentage of a number; decimal divided by a decimal; and multiply fractions (all from the old test).

Factor III was identified as Subtraction of Fractions. The objectives with the highest loadings on Factor III were two pairs of objectives from the two tests: subtract mixed numbers and subtract fractions (four objectives) and one old test objective, evaluate common algebraic expressions.

Factor IV was identified as Comparing Fractions.

The objectives with the highest loadings on Factor IV were: find the larger of two fractions; decimal times a decimal; and parts of a circle (all from the old test).

Factor V was identified as Multiplying Whole and Mixed Numbers. The objectives with the highest loadings on Factor V were one pair of objectives from the two tests: whole number times a mixed number (two objectives).

The factor matrix resulting from the iterated principal components analysis followed by varimax rotation of the 40 objectives not common to the old (1979) and new (1980) Grade 10 MEAP mathematics tests appears in Appendix C, Table C-15. The initial iterated principal components analysis resulted in six factors having eigenvalues greater than one which were rotated to simple structure using the varimax procedure. These six factors, together with the objectives loading on them, are presented in Figure 15.

Factor I was identified as Division. The objectives with the highest loadings on Factor I were: whole number division--word problems; whole number division--computation; multiplying decimals--word problems; decimal divided by a whole number; money word problems; convert mixed numbers to common fractions; probability of a simple event; time conversion; convert fractions to decimals; and volume computation (all from the new test).

FIGURE 15

FACTORS RESULTING FROM THE PRINCIPAL COMPONENTS ANALYSIS AND VARIMAX ROTATION OF THE 40 OBJECTIVES NOT COMMON TO THE OLD (1979) AND NEW (1980) VERSIONS OF THE GRADE 10 MEAP MATHEMATICS TEST (OLD AND NEW TEST SCORES RECODED*)

Factors Number/Name	Objectives Loading On Each Factor
I Division	Whole number division--word problems
	Whole number division--computation
	Multiplying decimals--word problems
	Decimal divided by a whole number
	Money word problems
	Convert mixed numbers to common fractions
	Probability of a simple event
	Time conversion
	Convert fractions to decimals
	Volume computation
II Using Charts and Graphs	Answer questions using a bar graph
	Given cost, what could be purchased
	Whole number division--computation
	Word problems--standard units of measure
	Convert common fractions to decimals
	Determine percentage of a given number
	Word problems--rectangles, triangles, circles
	Find a set of equivalent fractions
III Using Ratios	Multiply or divide money by a positive integer
	Write a ratio describing an indicated comparison
	Locate items in a table of data

(more)

FIGURE 15--Continued

Factors Number/Name	Objectives Loading On Each Factor
	Predict the number of times an event will occur Identify congruent and non-congruent figures
IV Geometry	Addition of fractions--word problems Area word problems Add fractions with unlike denominators Angle measurement Measure a triangle and find area Find perimeter of polygons and circles Write equivalent ratios by supplying the missing whole number
V Measurement	Find difference in time intervals Round to the nearest one, tenth, hundredth Measure object to the nearest unit Add integers
VI Algebra	Solve linear equations Whole number times a fraction Add mixed numbers Write an exponent as the product of factors Locate integers on a number line Decimal times a whole number power of ten

*Old test scores were recoded as follows:
0=0 1=1.5 2=1.5 3=3 4=3.

New test scores were recoded as follows:
0=0 1=1.5 2=1.5 3=3.

Factor II was identified as Using Charts and Graphs. The objectives with the highest loadings on Factor II were: answer questions using a bar graph; given cost, what could be purchased; whole number division--computation; word problems--standard units of measure; convert common fractions to decimals; determine percentage of a given number; word problems--rectangles, trangles, circles; and find a set of equivalent fractions (all from the old test).

Factor III was identified as Using Ratios. The objectives with the highest loadings on Factor III were: multiply or divide money by a positive integer; write a ratio describing an indicated comparison; locate items in a table of data; predict the number of times an event will occur; and identify congruent and non-congruent figures (all from the old test).

Factor IV was identified as Geometry. The objectives with the highest loadings on Factor IV were: addition of fractions--word problems; area word problems; add fractions with unlike denominators; angle measurement (from the new test); measure a triangle and find area; find perimeter of polygons and circles; and write equivalent ratios by supplying the missing whole number (from the old test).

Factor V was identified as Measurement. The objectives with the highest loadings on Factor V were: find difference in time intervals; round to the nearest one, tenth, hundredth; measure object to the nearest unit; and add integers (all from the old test).

Factor VI was identified as Algebra. The objectives with the highest loadings on Factor VI were: solve linear equations; whole number times a fraction; add mixed numbers; write an exponent as the product of factors; locate integers on a number line; and decimal times a whole number power of ten (all from the old test).

Factor scores were computed for each of the 557 students based upon the five factors extracted from the 14 pairs of common objectives and the six factors extracted from the 40 objectives not common to the two tests following recoding* of both the old and new test scores. Pearson product-moment correlation coefficients were computed on all pairs of sets of factor scores. The resulting correlation matrix appears in Appendix C, Table C-16. A summary of the intercorrelations among the factor scores is presented in Figure 16.

The results of this correlational analysis indicated that Factor I from the 14 pairs of common objectives, Fractions and Decimals (New Test), was most highly correlated with Factor I from the 40 objectives not common to the two tests, Division, (r=+.7487). Both were new test

*Old test scores were recoded as follows:
0=0 1=1.5 2=1.5 3=3 4=3.
New test scores were recoded as follows:
0=0 1=1.5 2=1.5 3=3.

factors.

Factor II from the 14 pairs of common objectives, Fractions and Decimals (Old Test), was highly correlated with Factors III, II, and V from the 40 objectives not common to the two tests, Using Ratios, Using Charts and Graphs, and Measurement, (r=+.7666, +.4081, and +.2028, respectively).

FIGURE 16

SUMMARY OF THE INTERCORRELATIONS AMONG FACTOR SCORES FOR THE 14 PAIRS OF COMMON OBJECTIVES AND THE 40 OBJECTIVES NOT COMMON TO THE OLD[a] (1979) AND NEW[b] (1980) VERSIONS OF THE GRADE 10 MEAP MATHEMATICS TEST

14 Pairs Of Common Objectives	40 Objectives Not Common					
	Factor I	Factor II	Factor III	Factor IV	Factor V	Factor VI
Factor I	0.7487*	0.0779	0.0227	0.3292	0.1794	0.1556
Factor II	0.0391	0.4081*	0.7666*	0.0687	0.2028*	0.1565
Factor III	0.2806	0.1117	-0.0282	0.3519	0.1930	0.5427*
Factor IV	0.1138	0.6360*	0.0581	0.2234	0.1395	0.1151
Factor V	0.1499	0.0988	0.0312	0.3939*	0.1026	0.1442

[a]Old test scores were recoded as follows:
0=0 1=1.5 2=1.5 3=3 4=3.

[b]New test scores were recoded as follows:
0=0 1=1.5 2=1.5 3=3.

*Asterisks indicate highest intercorrelations among factor scores.

Factor III from the 14 pairs of common objectives, Subtracting Fractions, was most highly correlated with Factor VI from the 40 objectives not common to the two tests, Algebra, (r=+.5427). Factor III from the 14 common objectives was defined by two pairs of common objectives from the old and new tests and one old test objective. Factor VI from the 40 objectives not common to the two tests was an old test factor.

Factor IV from the 14 common objectives, Comparing Fractions, was most highly correlated with Factor II from the 40 objectives not common to the two tests, Using Charts and Graphs, (r=+.6360). Both were old test factors.

Factor V from the 14 pairs of common objectives, Multiplying Whole and Mixed Numbers, was most highly correlated with Factor IV from the 40 objectives not common to the two tests, Geometry, (r=+.3939). Factor V from the 14 pairs of common objectives was defined by one pair of common objectives from the old and new tests. Factor IV from the 40 objectives not common to the two tests was also defined by a combination of old and new factors.

The transformation of both the old and new test objective scores was undertaken in order to equalize the range of scores on the two tests and to attempt to remove the bias which was observed in previous rescaling attempts. In order to investigate the effectiveness of this third transformation, means were computed for each of the 28 objective scores (14 old test and 14 new test) in the set of 14 common objectives. Each pair of objective score means was tested for equivalence using a correlated t-test (t-test for dependent groups) since the same individuals took both tests. The results of these analyses appear in Table 4. Only one pair of objectives was not significantly different ($\alpha = .05$): subtract fractions, as happened in the previous analysis. Likewise, only the objective, decimal times a decimal, indicated a difference in the opposite direction from that expected due to practice effect.

It was concluded that other attempts to remove bias by rescaling scores would provide no additional improvement.

The Impact on Decisions of the Use of Each Version

The final phase of the data analysis involved an investigation of the decisions which would result from the use of the old and new Grade 10 MEAP mathematics tests. Even though the factor analyses described above indicated that the two tests were not measuring the same traits, if the same decisions were likely to be made using either of

TABLE 4

CORRELATED t-TESTS ON OLD[a] AND NEW[b] TEST SCORES ON 14 PAIRS OF COMMON OBJECTIVES

Objectives	Old Test Mean (Std. Dev.)	New Test Mean (Std. Dev.)	t	df	Significance
Order a set of decimals	2.2864 (1.024)	1.9955 (1.133)	- 5.81	556	**
Decimal X decimal	2.0467 (1.199)	2.1921 (0.999)	+ 2.78	556	**
Decimal divided by decimal	1.8070 (1.088)	1.3761 (0.953)	- 8.88	556	**
Find the larger of two fractions	2.0278 (1.164)	1.8959 (1.207)	- 2.51	556	*
Multiply fractions	2.8142 (0.650)	2.3241 (1.072)	- 10.45	556	**
Convert fractions, decimals, percents	2.2163 (1.008)	1.8528 (0.913)	- 7.71	556	**
Word problems--find percentage of a number . . .	2.1786 (1.037)	1.8986 (1.035)	- 5.88	556	**
Find the mean of a set of numbers	2.3402 (0.925)	1.9578 (1.068)	- 8.48	556	**
Evaluate common algebraic expressions	2.1221 (1.104)	1.7343 (1.148)	- 9.16	556	**

(more)

TABLE 4--Continued

Objectives	Old Test Mean (Std. Dev.)	New Test Mean (Std. Dev.)	t	df	Significance
Read a coordinate system	2.7415 (0.772)	2.5664 (0.845)	- 4.15	556	**
Subtract fractions	1.9794 (1.268)	1.9336 (1.263)	- 0.92	556	NS
Subtract mixed numbers	1.8501 (1.220)	1.5431 (1.236)	- 6.61	556	**
Whole number X mixed number	1.2065 (1.340)	1.0314 (1.272)	- 3.18	556	**
Parts of a circle	1.9632 (1.125)	1.6750 (1.063)	- 5.54	556	**

[a]Old test scores were recoded as follows: 0=0 1=1.5 2=1.5 3=3 4=3.

[b]New test scores were recoded as follows: 0=0 1=1.5 2=1.5 3=3.

NS = not significant

* = $p < .05$

** = $p < .01$

the two tests, the underlying differences were less important.

The investigation of the decision making results centered around the proportions report data which would have resulted from the use of the old (1979) test in its entirety, the new (1980) test in its entirety, the 14 common objectives from each of the tests, the 14 remaining objectives from the new test and the 26 remaining objectives from the old test.

The Michigan Department of Education proportions reports indicate the percent of pupils achieving objectives in four categories: category #1 (0-25% achieved), category #2 (26-50% achieved), category #3 (51-75% achieved), and category #4 (76-100% achieved). Table 5 presents proportions reports based upon six sets of items from the Grade 10 MEAP mathematics tests: 14 common objectives from the old test, 14 common objectives from the new test, 26 objectives from the old test not appearing on the new test, 14 objectives from the new test not appearing on the old test, all 40 objectives from the old test, and all 28 objectives from the new test.

Examination of the data in Table 5 confirms the findings stated above. The two forms of the Grade 10 MEAP mathematics test classify the same students in different ways.

TABLE 5

PROPORTIONS REPORTS BASED UPON SIX SETS OF ITEMS
GRADE 10 MEAP MATHEMATICS TESTS (N = 557)

Item Set	MEAP Category*							
	1		2		3		4	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Old Test -- 14 Common	82	14.7%	164	29.4%	125	22.4%	186	33.4%
New Test -- 14 Common	56	10.1	139	25.0	122	21.9	240	43.1
Old Test -- 26 Different	77	13.8	157	28.2	175	31.4	148	26.6
New Test -- 14 Different	76	13.6	135	24.2	124	22.3	222	39.9
Old Test -- All 40	88	15.8	141	25.3	158	28.4	170	30.5
New Test -- All 28	63	11.3	135	24.2	141	25.3	218	39.1

*MEAP categories are based upon the percent of objectives achieved:

Category 1: 0% - 25%
Category 2: 26% - 50%
Category 3: 51% - 75%
Category 4: 76% - 100%

A comparison of the two sets of 14 common objectives indicates that nearly 10% more students would have been classified as category #4 if they had taken the new test than if they had taken the old test. Also, nearly 5% fewer students would have been classified as category #1 under the same circumstances. This finding is even more unusual given that students took the new test first.

The shift in category #4 was even more dramatic when the 14 different objectives from the new test were compared to the 26 different objectives from the old test. Here the new test raised the percentage of students in category #4 over 13% while category #1 remained almost constant.

Comparing the two tests in their entirety with respect to proportions data produced similar results. Category #4 increased nearly 9% from old test to new test while category #1 decreased 4.5%

The Michigan Department of Education assigns a status and change definition to schools based upon three consecutive years of Michigan Educational Assessment Program data. The status assigned to a school is determined by the percent of students in category #4. Schools with fewer than 50% of their students in category #4 for two out of three years are classified as high needs schools. According to this definition, if the results of this study represented data for more than one year, the schools from which the sample of students in this study were taken would be classified as high needs schools.

The change definition assigned to a school is also based upon three years of data. Three criteria must be satisfied in order to define a school as "improving" on MEAP results: (1) there has been an increase of at least 5% in category #4 from year one to year three, (2) there has been at least a 5% decrease in category #1 from year one to year three, and (3) during year two, categories #1 and #4 remained stable, i.e., the increase and decrease lasted for more than one year. Since data presented here can represent, at most, two years, only the first two criteria can be applied. The results in Table 5 indicate that by changing from the old (1979) test to the new (1980) test, a school might be classified as improving even though only three weeks separated the administrations of the tests.

One additional explanation for these results was explored. This explanation rests on the fact that the new test required students to have correct answers to at least two out of three questions in order to achieve an objective while the old test required that at least three out of four questions be answered correctly. Assuming that all questions were four-item multiple choice, the probability of achieving an objective on the old test, by chance, was 13/256 or .051, while the probability of achieving an objective on the new test, by chance, was 10/64 or .156.

The old test consisted of 40 objectives. Using the binominal distribution, the probability of a student achieving 76-100% of the objectives (being classified in category #4) on the old test, by chance, was 5.676×10^{-41}.

The new test consisted of 28 objectives. Using the binominal distribution, the probability of a student achieving 76-100% of the objectives (being classified in category #4) on the new test, by chance, was 7.862×10^{-19}.

This means that the probability of scoring in category #4, by chance, on the new test is 1.385×10^{22} times as great as the probability of scoring in category #4, by chance, on the old test.

Summary

To summarize, this chapter includes the results of the exploration of two forms of the Grade 10 MEAP mathematics test.

First, four correlational analyses were presented. These analyses examined relationships among objective scores and total scores and traditional reliability coefficients.

Next, eleven factor analyses were presented. Each test was factor analyzed separately. The two tests were factor analyzed together. Four sets of two analyses were conducted dividing the two tests into a set of 14 pairs of common objectives and a set of 40 objectives not common to the two tests. These latter eight factor analyses were performed using three rescaling schema in an effort to remove the method effect observed in the third factor analysis. For each of the four sets of two factor analyses and for the old and new test factors, factor scores were computed and correlations among factor scores were computed in an effort to examine the relationships among the factors produced. The results of these analyses indicated that the two tests were different.

Finally, the decisions which would result from using different forms of the Grade 10 MEAP mathematics tests were examined. Proportions data based upon the Michigan Department of Education's criteria were generated for six sets of objectives. The probability of students scoring in the highest category, by chance, on each of the two tests was also examined. These comparisons indicated that changing from the old to the new form of the test could, simply by chance, result in dramatic changes in classification of students and schools.

CHAPTER V

Summary, Conclusions, and Recommendations

This chapter has answers to the questions posed in Chapter I and makes recommendations for future applications of the model described in this study.

Summary of Results and Answers to Questions

This study involved a detailed analysis of the factor structure of two forms of the Grade 10 MEAP mathematics test. The subjects were 557 grade ten students from five volunteer high schools who took the new (1980) form of the Grade 10 MEAP mathematics test during the regularly scheduled administration period in the fall of 1980 and then took the old (1979) form of the Grade 10 MEAP mathematics test approximately three weeks later.

The old and new forms of the Grade 10 MEAP mathematics test varied in several aspects. The old form tested 40 objectives using four items per objective with a criterion for success of at least three correct while the new form tested 28 objectives using three items per objective with a criterion for success of at least two correct. The two forms shared 14 common objectives.

Furthermore, identical test items measuring the 14 objectives appeared on both the old and the new form with one additional similar item included on the old form for each objective.

Data for this study were obtained from the Michigan Research, Evaluation and Assessment Services Department.

The initial analysis consisted of four correlational analyses which examined relationships among objective scores and total scores and traditional reliability coefficients.

The major exploratory analyses consisted of eleven factor analyses. First, each of the two forms of the test was factor analyzed separately. The results of these analyses are summarized in Figure 17. The results indicated that the new test had three factors: Fractions, Algebraic Operations and Formulas; Decimals; and Division, while the old test had five factors: Arithmetic: Whole Number and Decimal Multiplication and Division; Algebraic Operations and Fractions; Ratio, Proportion and Probability; Metric Measurement; and Non-Metric Measurement. This result led to nine additional exploratory analyses. The first was to subject all 68 objectives from the two tests to a single factor analysis. The results of this analysis indicated that objectives from the two tests did not load on the same factor pointing toward a probable method effect.

FIGURE 17

FACTORS RESULTING FROM ELEVEN FACTOR ANALYSES OF TWO VERSIONS OF THE GRADE 10 MEAP MATHEMATICS TEST

Description Of Analysis	Resulting Factors	
	Number	Name
New Test: All 28 Objectives	I.	Fractions, Algebraic Operations and Formulas
	II.	Decimals
	III.	Division
Old Test: All 40 Objectives	I.	Arithmetic : Whole Number and Decimal Multiplication and Division
	II.	Algebraic Operations and Fractions
	III.	Ratio, Proportion and Probability
	IV.	Metric Measurement
	V.	Non-Metric Measurement
Old and New Test: 68 Objectives	I.	Arithmetic Computation
	II.	Word Problems Involving Standard Units of Measure
	III.	Word Problems
	IV.	Algebra
	V.	Fractions
	VI.	Geometry
	VII.	Decimal Division
Old and New Test: 14 Common Objectives (No Recoding)	I.	Decimals and Percents (New Test)
	II.	Decimals and Percents (Old Test)
	III.	Fractions
	IV.	Algebra
Old and New Test: 40 Objectives not Common to the Two Tests (No Recoding)	I.	Word Problems
	II.	Algebra
	III.	Using Standard Units of Measure
	IV.	Non-Metric Measurement
	V.	Using Charts and Graphs

(more)

FIGURE 17--Continued

Description Of Analysis	Resulting Factors Number	Name
Old and New Test: 14 Common Objectives Recode Old Test: 0=0, 1=0, 2=1, 3=2, 4=3.	I.	Decimals and Percents (New Test)
	II.	Subtraction of Fractions
	III.	Decimals and Percents (Old Test)
	IV.	Algebra
	V.	Division
Old and New Test: 40 Objectives not Common to the Two Tests--Recode Old Test: 0=0, 1=0, 2=1, 3=2, 4=3.	I.	Geometric Measurement
	II.	Division
	III.	Using Charts and Graphs
	IV.	Algebra
	V.	Addition of Fractions Word Problems
Old and New Test: 14 Common Objectives Recode Old Test: 0=0, 1=1.5, 2=1.5, 3=3, 4=3.	I.	Decimals (New Test)
	II.	Decimals (Old Test)
	III.	Fractions
	IV.	Comparing Fractions
Old and New Test: 40 Objectives not Common to the Two Tests--Recode Old Test: 0=0, 1=1.5, 2=1.5, 3=3, 4=3.	I.	Division
	II.	Using Charts and Graphs
	III.	Geometry
	IV.	Using Ratios
	V.	Algebra
	VI.	Fractions
Old and New Test: 14 Common Objectives Recode Old Test: 0=0, 1=1.5, 2=1.5, 3=3, 4=3. Recode New Test: 0=0, 1=1.5, 2=1.5, 3=3.	I.	Fractions and Decimals (New Test)
	II.	Fractions and Decimals (Old Test)
	III.	Subtraction of Fractions
	IV.	Comparing Fractions
	V.	Multiplying Whole and Mixed Numbers.
Old and New Test: 40 Objectives not Common to the Two Tests--Recode Old Test: 0=0, 1=1.5, 2=1.5, 3=3, 4=3. Recode New Test: 0=0, 1=1.5, 2=1.5, 3=3.	I.	Division
	II.	Using Charts and Graphs
	III.	Using Ratios
	IV.	Geometry
	V.	Measurement
	VI.	Algebra

Subsequent analyses were conducted in sets of two. One set of objectives analyzed together was the 14 pairs of common objectives from the two tests. The other set was the 40 remaining objectives (14 from the new test, 26 from the old test) which were not common to the two tests.

These two sets of objectives were subjected to four factor analyses. The first simply used the unchanged objective scores. The results indicated that the method factor persisted even when the 14 pairs of common objectives were analyzed separately. The second, third, and fourth analyses attempted to account for this observed phenomenon by rescaling the old test objective scores in two different ways and, finally, by also rescaling the new test objective scores.

None of these procedures succeeded in producing factors which, in general, were defined by objectives from the old and new tests which were identical and/or similar. The two tests continued to load on different factors.

With the exception of the second analysis where all 68 objectives were factor analyzed together, each of the pairs of analyses was subjected to a second order analysis where factor scores were computed for each of the subjects on each of the factors, and correlation matrices were produced in order to investigate the relationships among the factors. In these second order analyses, factors from the 14 common objectives which were defined by objectives from the old version of the test were more highly correlated with factors from the 40 objectives not common to the two tests which were also defined by objectives from the old version of the test. Likewise, factors from the 14 common objectives with highest loadings from the new version were most highly correlated with factors from the 40 objectives not common to the two tests which were defined by objectives from the new version of the test.

The final phase of the analysis consisted of an examination of the impact that the apparent differences in the two tests would have on decisions based upon MEAP data. These results indicated that the decisions made, using the two instruments, would lead to different conclusions, at least for this sample of students.

The first question posed in Chapter I was, "What is the correlation between the number of items correct and the number of objectives achieved on the old version of the Grade 10 MEAP mathematics test?" The correlation between the number of items correct and the number of objectives achieved was +.9805.

The second question posed in Chapter I was, "What is the correlation between the number of items correct and the number of objectives achieved on the new version of the Grade 10 MEAP mathematics test?" The correlation between the number of items correct and the number of objectives achieved was +.9833.

The third question posed in Chapter I was, "What is the correlation between the total score (number correct) on each of the two versions of the Grade 10 MEAP mathematics test?" The correlation between the total scores on the two versions was +.7991.

The fourth question posed in Chapter I was, "What is the correlation between the number of objectives achieved on each of the two versions of the Grade 10 MEAP mathematics test?" The correlation between the numbers of objectives achieved on the two versions was +.8072.

The fifth question posed in Chapter I was, "What is the underlying factor structure of the old version of the Grade 10 MEAP mathematics test?" The old version of the Grade 10 MEAP mathematics test measured five factors: (1) arithmetic: whole number and decimal multiplication and division; (2) algebraic operations and fractions; (3) ratio, proportion, percent and probability; (4) metric measurement; and (5) non-metric measurement.

The sixth question posed in Chapter I was, "To what extent does the factor structure of the old version of the Grade 10 MEAP mathematics test match the ten skill areas to which the objectives are assigned by the MEAP staff on the proportions report?" The proportions report indicated that the old Grade 10 MEAP mathematics test measured ten skill areas: (1) whole number division; (2) fractions; (3) decimals; (4) integers; (5) ratio, proportion, percent; (6) geometric measurement; (7) non-geometric measurement; (8) geometry; (9) algebra; and (10) probability and statistics. The resulting factor structure revealed only five factors: (1) arithmetic: whole number and decimal multiplication and division; (2) algebraic operations and fractions; (3) ratio, proportion, percent and probability; (4) metric measurement; and (5) non-metric measurement.

The distribution of the objectives from the old (1979) version of the Grade 10 MEAP mathematics test by skill area and factor loading appears in Figure 18. The first skill area, whole number division, consisted of one objective. This objective loaded on Factor I, Arithmetic: Whole Number and Decimal Multiplication and Division. The eight objectives assigned to the second skill area, fractions, loaded on three factors: Factor I, Arithmetic: Whole Number and Decimal Multiplication and Division, Factor II, Algebraic Operations and Fractions, and Factor V, Non-Metric Measurement. The six objectives assigned to the third skill area, decimals, loaded on three factors: Factor I, Arithmetic: Whole

FIGURE 18

DISTRIBUTION OF OBJECTIVES[a] FROM THE OLD (1979) VERSION OF THE GRADE 10 MEAP MATHEMATICS TEST BY SKILL AREA AND FACTOR LOADING

Skill Areas	Factor I Arithmetic: Whole Number and Decimal Multiplication and Division	Factor II Algebraic Operations and Fractions	Factor III Ratio, Proportion and Probability	Factor IV Metric Measurement	Factor V Non-Metric Measurement
Whole Number Division	1				
Fractions	3, 2, 4	6, 5, 8, 9			7
Decimals	14, 11	13, 15, 10	12		
Integers		16, 17			
Ratio, Proportion, Percent	21		18, 20, 22	19	
Geometric Measurement	25, 29		26, 27	24, 23, 28	
Non-Geometric Measurement	31		32		30
Geometry	33				34
Algebra		37, 35, 36			
Probability and Statistics	38	40	39		

[a]Numbers in the body of the figure refer to objective numbers listed in Appendix A.

Number and Decimal Multiplication and Division, Factor II, Algebraic Operations and Fractions, and Factor III, Ratio, Proportion and Probability. The two objectives assigned to the Integers skill area loaded on Factor II, Algebraic Operations and Fractions. The five objectives assigned to the Ratio, Proportion, Percent skill area loaded on three factors: Factor I, Arithmetic: Whole Number and Decimal Multiplication and Division, Factor III, Ratio, Proportion and Probability, and Factor IV, Metric Measurement. The seven objectives assigned to the Geometric Measurement skill area loaded on three factors: Factor I, Arithmetic: Whole Number and Decimal Multiplication and Division, Factor III, Ratio, Proportion and Probability, and Factor IV, Metric Measurement. The three objectives assigned to the Non-Geometric Measurement skill area loaded on three factors: Factor I, Arithmetic: Whole Number and Decimal Multiplication and Division, Factor III, Ratio, Proportion and Probability, and Factor V, Non-Metric Measurement. The two objectives assigned to the Geometry skill area loaded on two factors: Factor I, Arithmetic: Whole Number and Decimal Multiplication and Division, and Factor V, Non-Metric Measurement. All three objectives assigned to the Algebra skill area loaded on

Factor II, Algebraic Operations and Fractions. The three objectives assigned to the Probability and Statistics skill area loaded on three factors: Factor I, Arithmetic: Whole Number and Decimal Multiplication and Division, Factor II, Algebraic Operations and Fractions, and Factor III, Ratio, Proportion and Probability.

The seventh question posed in Chapter I was, "What is the underlying factor structure of the new version of the Grade 10 MEAP mathematics test?" The new version of the Grade 10 MEAP mathematics test measured three factors: (1) fractions, algebraic operations and formulas; (2) decimals; and (3) division.

The eighth question posed in Chapter I was, "To what extent does the factor structure of the new version of the Grade 10 MEAP mathematics test match the nine skill areas to which the objectives are assigned by the MEAP staff on the proportions report?" The proportions report indicated that the new version of the Grade 10 MEAP mathematics test measured nine skill areas: (1) whole numbers; (2) decimals; (3) fractions; (4) ratio, proportion, percent; (5) metric measurement; (6) non-metric measurement; (7) geometry; (8) probability and statistics; and (9) equations, expressions and graphs. The resulting factor structure revealed only three factors: (1) fractions, algebraic operations and formulas; (2) decimals; and (3) division.

FIGURE 19

DISTRIBUTION OF OBJECTIVES[a] FROM THE NEW (1980) VERSION OF THE GRADE 10 MEAP MATHEMATICS TEST BY SKILL AREA AND FACTOR LOADING

Skill Areas	Factors I: Fractions, Algebraic Operations and Formulas	Factors II: Decimals	Factors III: Division
Whole Numbers			2, 1
Decimals		6, 4, 7, 8	3, 5
Fractions	11, 12, 14, 13, 16, 10	15	9
Ratio, Proportion, Percent		18	17
Metric Measurement	19, 20		
Non-Metric Measurement	21	23	22
Geometry	24		
Probability and Statistics		26, 25	
Equations, Expressions and Graphs	27		28

[a]Numbers in the body of the figure refer to objective numbers listed in Appendix A.

The distribution of the objectives from the new (1980) version of the Grade 10 MEAP mathematics test by skill area and factor loading appears in Figure 19. The two objectives assigned to the first skill area, whole numbers, both loaded on Factor III, Division. The six objectives assigned to the Decimals skill area loaded on two factors: Factor II, Decimals and Factor III, Division. Six of the eight objectives assigned to the Fractions skill area loaded on Factor I, Fractions, Algebraic Operations and Formulas; one of the remaining two loaded on Factor II, Decimals, while the other loaded on Factor III, Division. The two objectives assigned to the Ratio, Proportion, Percent skill area loaded on two factors: Factor II, Decimals and Factor III, Division. Both of the objectives assigned to the Metric Measurement skill area loaded on Factor I, Fractions, Algebraic Operations and Formulas. The one objective assigned to the Geometry skill area loaded on Factor I, Fractions, Algebraic Operations and Formulas. The two objectives assigned to the Probability and Statistics skill area loaded on Factor II, Decimals. The two objectives assigned to the Equations, Expressions and Graphs skill area loaded on Factor I, Fractions, Algebraic Operations and Formulas, and Factor III, Division.

The ninth question posed in Chapter I was, "Can the two versions of the Grade 10 MEAP mathematics test be said to be equivalent based upon correlations among factor scores derived from the factor analyses of the two versions of the test?" Using factor scores for each of the subjects in the study, a statistically significant correlation was found between each of the factors from the old version of the test and at least one of the factors from the new version. It should be noted, however, that only one of these correlations exceeded +.50 (the correlation between Factor II from the old version of the test: Algebraic Operations and Fractions with Factor I from the new version of the test: Fractions, Algebraic Operations and Formulas, r=+.6460). The statistical significance was a function of the number of cases (N=557) rather than an indication of the equivalence of the factors extracted from the two versions of the test.

The tenth question posed in Chapter I was, "Are decisions based upon the results of the old and new versions of the Grade 10 MEAP mathematics test likely to be the same regardless of which form of the test is used?" Decisions made, based upon MEAP data, focus upon the proportions report which reports percent of students scoring in four categories: Category #1 (0-25% of the objectives achieved), Category #2 (26-50% of the objectives achieved), Category #3 (51-75% of the objectives achieved), and Category #4 (76-100% of the objectives achieved). Data from this study indicated that when students were administered the new (1980) version of the test, followed approximately three weeks later by the old (1979) version of the test, the proportion of students in Category #1 increased by 4.5% while the proportion of students in Category #4 declined by 8.6%. These changes indicated that students taking the new (1980) version of the test were more likely to score in Category #4 than those taking the old (1979) version of the test. According to the MDE definition, schools could become "improving schools" due to the use of the new version of the test even though their students had no additional learning. Similar results were observed when only the 14 common objectives were used to construct proportions data. Based upon the results of this study, decisions based upon results of the old and new versions of the Grade 10 MEAP mathematics test will not be the same.

Conclusions

The major conclusions of this study were that the old (1979) and new (1980) versions of the Grade 10 MEAP mathematics test were different in factor structure and in the classification of pupils which resulted when they were used.

The factor structure of the old version involved five factors: I. Arithmetic: Whole Number and Decimal Multiplication and Division; II. Algebraic Operations and Fractions; III. Ratio, Proportion and Percent; IV. Metric Measurement; and V. Non-Metric Measurement. The factor structure of the new version involved three factors: I. Fractions, Algebraic Operations and Formulas; II. Decimals; and III. Division. The secondary analysis of these data, which involved computing correlations among factor scores on all pairs of factors from the two tests, resulted in only one correlation coefficient which exceeded +.50: the correlation between Factor I from the new version: Fractions, Algebraic Operations and Formulas and Factor II from the old version: Algebraic Operations and Formulas ($r=+.6460$). All other correlations, although statistically significant, were low in practical terms. This indicated that the two versions of the test were measuring different traits, at least from a factor analytic perspective.

Further analyses involved factoring two subsets of items from the two versions of the test. One subset consisted of 14 pairs of objectives which were common to the two forms. This commonality involved three identical items on the two versions for each of the 14 objectives with one additional item, similar to the other three, appearing on the old version. It was hypothesized that if the two versions were measuring the same traits, this would be most apparent on this subset of objectives. The results of this analysis indicated that the two versions seemed to be measuring different traits on these 14 pairs of common objectives. The two members of each common pair consistently loaded on different factors indicating that the method of assessment (i.e., old versus new version of the test) was more likely to differentiate among items than the actual content of the items, even when the content was identical.

The method variance observed when the 14 pairs of common objectives were factor analyzed separately also appeared when the 40 remaining objectives from the two tests were subjected to factor analysis. The version of the test from which the items were taken was more likely to predict which items loaded on a factor than the similarity of content contained in the items.

Three recoding schema were used in an attempt to account for this method variance. All failed to produce the desired results.

The differences in the two versions of the test were not detected by merely examining the correlation between the total scores on the two tests ($r=+.7991$) nor the correlation between the numbers of objectives achieved on the two tests (r=+.8072). Both of these coefficients indicated that the two tests have high alternate forms reliability. They were, however, not measuring the same traits. For example, the new version had no measurement factors while the old version had two: Factor IV. Metric Measurement and Factor V. Non-Metric Measurement. Also, the correlations among the factors from the two versions were low in practical terms (less than +.50) in all but one case (the correlation between Factor I from the new version: Fractions, Algebraic Operations and Formulas and Factor II from the old version: Algebraic Operations and Formulas, r=+.6460).

The major implication of these findings is that assertions that two tests measure the same traits--even when the same items are used in a different configuration--are tenuous at best.

With respect to the classification of pupils, it was found that pupils taking the new version of the test were more likely to score in Category #4 (76-100% of the objectives achieved) and less likely to score in Category #1 (0-25% of the objectives achieved) on the new version than on the old version of the test. These differences were 8.6% and 4.5%, respectively. Changes of this magnitude are considered to be significant by MEAP standards.

Recommendations

The major limitation of this study was that the researcher had no control over the conditions under which the tests were administered. If this study is replicated, the two tests should be administered in a random order so that the possible confounding factors of fatigue and practice effect may be controlled. Also, some supervision of the testing conditions and procedures should be used in order to assure that the tests are administered under standard conditions.

The model developed in this study involved factor analyzing two forms of an objective-referenced test and attempting to equate these factors by computing correlations among factor scores for subjects on each of the factors produced from the two forms. It is recommended that future revisions of the MEAP test be analyzed using this model, with the precautions suggested above, in order to be confident that there is some continuity across forms of the test, especially if important decisions, such as the distribution of compensatory education monies, are to be based upon longitudinal data.

Problems for Further Study

The research reported here applied a factor analytic model for equating two versions of an objective-referenced test. The following problems are suggested for further study in the application and refinement of the model developed.

1. How does the model developed in this study for equating forms on an objective-referenced test apply to alternate forms of a norm-referenced test? Are the results similar to those derived from the traditional correlational methods?

2. Does the skewed distribution of scores which frequently results on on objective-referenced test (i.e., most students responding correctly to most items) effect the factor solution when the results are factor analyzed at the objective score level of analysis?

3. Does the number of items used to measure an objective have an impact upon the factor structure of an objective-referenced test? If so, is there a relationship between the number of items and the stability of the factor structure?

4. Are objective-referenced tests which are constructed using the Rasch model more factor pure than those constructed using traditional methods?

5. Are alternate forms constructed using the Rasch model more likely to have similar factor structures than those constructed using traditional methods?

A P P E N D I C E S

APPENDIX A

Objectives and Skill Areas Assessed on the Old and New Grade Ten Michigan Educational Assessment Program Mathematics Tests

GRADE TEN MATHEMATICS
Old MEAP Test

Skill Areas and Objectives[a]
WHOLE NUMBER DIVISION:
Computation (O 1)
FRACTIONS:
Find a Set of Equivalent Fractions (O 2)
Find the Larger of Two Fractions (O 3)*
Add Mixed Numbers (O 4)
Subtract Fractions with Unlike Denominators (O 5)*
Subtract Mixed Numbers with Unlike Denominators (O 6)*
Multiply Fractions (O 7)*
Whole Number X Fraction (O 8)
Whole Number X Mixed Number (O 9)*
DECIMALS:
Round to Nearest 1, .1, .01 (O 10)
Convert Common Fraction to Decimal (O 11)
Order a Set of Decimals (O 12)*
Decimal X Whole Number Power of 10 (O 13)
Decimal X Decimal (O 14)*
Decimal Divided by Decimal (O 15)*
INTEGERS:
Locate Integers on a Number Line (O 16)
Add Integers (O 17)
RATIO, PROPORTION, PERCENT:
Write Ratio Describing Indicated Comparison (O 18)
Write Equivalent Ratio--Supply Whole Number (O 19)
Convert Fractions, Decimals, Percents (O 20)*
Determine Percentage of Given Number (O 21)
Word Problems--Find Percentage of a Number (O 22)*

(more)

GRADE TEN MATHEMATICS
Old MEAP Test (Continued)

Skill Areas and Objectives[a]
GEOMETRIC MEASUREMENT:
Measure Object to Nearest Unit (O 23)
Find Perimeter of Polygons & Circles (O 24)
Word Problems--Standard Units of Measure (O 25)
Read a Coordinate System (O 26)*
Locate Items in a Table of Data (O 27)
Measure Triangle & Find Area (O 28)
Word Problems--Rectangles, Triangles, Circles (O 29)
NON-GEOMETRIC MEASUREMENT:
Find Difference in Time Intervals (O 30)
Given Cost, What Could be Purchased (O 31)
Multiply/Divide Money by Positive Integer (O 32)
GEOMETRY:
Identify Parts of a Circle (O 33)*
Identify Congruent & Non-Congruent Figures (O 34)
ALGEBRA:
Solve Linear Equation (O 35)
Write R**N as N Factors of R (O 36)
Evaluate Common Algebraic Expressions (O 37)*
PROBABILITY AND STATISTICS:
Answer Questions Using Bar Graph (O 38)
Predict Number of Times Event Will Occur (O 39)
Find the Mean of a Set of Numbers (O 40)

*These objectives were common to the old and new tests.

[a]As they appear on the proportions report forms for the old version of the Grade 10 MEAP mathematics test.

GRADE TEN MATHEMATICS
New MEAP Test

Skill Areas and Objectives[b]
WHOLE NUMBER DIVISION:
Computation (N 1)
Word Problems (N 2)
DECIMALS:
Convert Fractions to Decimals (N 3)
Order a Set of Decimals (N 4)*
Decimal X Decimal (N 5)*
Word Problems: Multiplication (N 6)
Decimal Divided by Whole Number (N 7)
Decimal Divided by Decimal (N 8)*
FRACTIONS:
Find the Larger of Two Fractions (N 9)*
Convert Mixed Numbers to Common Fractions (N 10)
Add Fractions with Unlike Denominators (N 11)
Addition Word Problems (N 12)
Subtract Fractions with Unlike Denominators (N 13)*
Subtract Mixed Numbers with Unlike Denominators (N 14)*
Multiply Fractions (N 15)*
Whole Number X Mixed Number (N 16)*
RATIO, PROPORTION, PERCENT:
Convert Fractions, Decimals, Percents (N 17)*
Word Problems--Find Percentage of a Number (N 18)*
METRIC MEASUREMENT:
Area Word Problems (N 19)
Volume Computation (N 20)
NON-METRIC MEASUREMENT:
Angle Measurement (N 21)
Time Conversion (N 22)
Money Word Problems (N 23)

(more)

GRADE TEN MATHEMATICS
New MEAP Test (Continued)

Skill Areas and Objectives[b]
GEOMETRY:
Identify Parts of a Circle (N 24)*
PROBABILITY AND STATISTICS:
Probability of a Simple Event (N 25)
Find the Mean of a Set of Numbers (N 26)*
EQUATIONS, EXPRESSIONS, GRAPHS:
Evaluate Common Algebraic Expressions (N 27)*
Read a Coordinate System (N 28)*

*These objectives were common to the old and new tests.

[b]As they appear on the proportions report forms for the new version of the Grade 10 MEAP mathematics test.

APPENDIX B

Schools Participating in the Study

APPENDIX B

Schools Participating in the Study

Five high schools volunteered to participate in the administration of both the old and new version of the Grade 10 Michigan Educational Assessment Program mathematics test. They were Mackinaw City High School in Cheboygan County, Chassell High School in Houghton County, Hudson High School in Lenawee County, Peck High School in Sanilac County, and Detroit Southeastern High School in Wayne County. These high schools represent metropolitan core cities, urban fringe areas, and rural areas in upper and lower Michigan.

The numbers of students from each school who participated in this study appear in Table B-1 below.

TABLE B-1
Numbers of Participating Students By High School

School	Number Of Students
Mackinaw City H.S.	22
Chassell H.S.	22
Hudson H.S.	104
Peck H.S.	46
Southeastern H.S.	363
Total	557

APPENDIX C

Rotated Factor Matrices

TABLE C-1

ROTATED FACTOR MATRIX
NEW (1980) GRADE 10 MEAP MATHEMATICS TEST
ALL OBJECTIVES

Objectives	Factors**		
	I	II	III
FRACTIONS: ADD FRACTIONS WITH UNLIKE DENOMINATORS (N 11)	.68207	.18119	.24833
FRACTIONS: ADDITION WORD PROBLEMS (N 12)	.65086	.21991	.18231
FRACTIONS: SUBTRACT MIXED NUMBERS UNLIKE DENOMINATORS (N 14)*	.60874	.29675	.34516
FRACTIONS: SUBTRACT FRACTIONS UNLIKE DENOMINATORS (N 13)*	.57055	.20217	.43425
FRACTIONS: WHOLE NUMBER X MIXED NUMBER (N 16)*	.52681	.23048	.12772
EQUATIONS EXP GRAPHS: EVALUATE COMMON ALG EXP (N 27)*	.48970	.43525	.38357
METRIC MEAS: AREA WORD PROBLEMS (N 19)	.46982	.35127	.16363
FRACTIONS: CONVERT MIXED NOS. TO COMMON FRACTIONS (N 10)	.45452	.42982	.28537
METRIC MEAS: VOLUME COMPUTATION (N 20)	.43432	.25905	.39841
NON-METRIC MEAS: ANGLE MEASUREMENT (N 21)	.39261	.36565	.12925
GEOMETRY: PARTS OF A CIRCLE (N 24)*	.36054	.24216	.25875
FRACTIONS: MULTIPLY FRACTIONS (N 15)*	.13412	.59788	.27724
DECIMALS: WORD PROBLEMS, MULTIPLICATION (N 6)	.32453	.58079	.34172
RATIO PROP %: WORD PROBLEM--FIND PERCENTAGE OF A NUMBER (N 18)*	.40609	.57036	.22358
DECIMALS: ORDER SET OF DECIMALS (N 4)*	.21875	.55742	.26864
NON-METRIC MEAS: MONEY WORD PROBLEMS (N 23)	.28543	.53964	.23395
DECIMALS: DECIMAL DIVIDED BY WHOLE NUMBER (N 7)	.43957	.51063	.30974
PROB & STAT: FIND THE MEAN OF A SET OF NUMBERS (N 26)*	.31977	.47217	.37118

TABLE C-1--Continued

Objectives	Factors**		
	I	II	III
PROB & STAT: PROBABILITY OF A SIMPLE EVENT (N 25)	.41772	.42062	.30830
DECIMALS: DECIMAL DIVIDED BY DECIMAL (N 8)*	.33441	.37308	.23686
WHOLE NUMBER DIVISION: WORD PROBLEMS (N 2)	.24401	.38531	.64759
WHOLE NUMBER DIVISION: COMPUTATION (N 1)	.12476	.43492	.59289
NON-METRIC MEAS: TIME CONVERSION (N 22)	.35457	.24763	.58591
DECIMALS: CONVERT FRACTIONS TO DECIMALS (N 3)	.50720	.20356	.53563
EQUATIONS EXP GRAPHS: READ A COORDINATE SYSTEM (N 28)*	.21111	.29887	.51888
DECIMALS: DECIMAL X DECIMAL (N 5)*	.21384	.46367	.50585
FRACTIONS: FIND THE LARGER OF TWO FRACTIONS (N 9)*	.43826	.23482	.45030
RATIO PROP %: CONVERT FRACTIONS DECIMALS PERCENTS (N 17)*	.35642	.19781	.44037

*These objectives appeared on both forms.

**Objectives are arranged according to factor loadings. The highest factor loading for each objective is contained in a rectangle.

TABLE C-2

ROTATED FACTOR MATRIX
OLD (1979) GRADE 10 MEAP MATHEMATICS TEST
ALL OBJECTIVES

Objectives	Factors**				
	I	II	III	IV	V
PROB & STAT: ANSWER QUESTIONS USING BAR GRAPH (O 38)	.69570	.17874	.23064	.19003	.25049
DECIMALS: DECIMAL X DECIMAL (O 14)*	.65964	.26572	.31172	.09254	.05090
GEOM MEAS: WORD PROBLEM--STANDARD UNITS OF MEASURE (O 25)	.65071	.28309	.22263	.33798	.07498
NON-GEOM MEAS: GIVEN COST, WHAT COULD BE PURCHASED (O 31)	.63351	.13861	.45300	.05250	.22858
WHOLE NUMBER DIVISION: COMPUTATION (O 1)	.63184	.33651	.42878	-.00910	.11415
FRACTIONS: FIND THE LARGER OF TWO FRACTIONS (O 3)*	.60212	.29178	.17709	.29188	.15650
DECIMALS: CONVERT COMMON FRACTION TO DECIMAL (O 11)	.57312	.35902	.14318	.37132	.05915
RATIO PROP %: DETERMINE PERCENTAGE OF GIVEN NUMBER (O 21)	.53159	.21626	.25626	.24743	.05117
GEOM MEAS: WORD PROB--RECTANGLES, TRIANGLES, CIRCLES (O 29)	.51698	.30968	.16026	.35747	.05476
GEOMETRY: PARTS OF A CIRCLE (O 33)*	.51035	.17612	.34539	.28867	.08532
FRACTIONS: FIND A SET OF EQUIVALENT FRACTIONS (O 2)	.45492	.35611	.36696	.21485	.08334
FRACTIONS: ADD MIXED NUMBERS (O 4)	.21277	.71981	.08940	.17981	.09669
FRACTIONS: SUBTRACT MIXED NUMBERS UNLIKE DENOMINATORS (O 6)*	.20306	.70389	.14209	.09812	.02163
FRACTIONS: SUBTRACT FRACTIONS UNLIKE DENOMINATORS (O 5)*	.53462	.57477	.27719	.04296	.07768
ALGEBRA: EVALUATE COMMON ALG EXP (O 37)*	.28031	.56016	.11892	.37452	.26930
DECIMALS: DECIMAL X WHOLE NO. POWER OF 10 (O 13)	.22533	.50817	.32719	.18679	.08372

TABLE C-2--Continued

Objectives	Factors**				
	I	II	III	IV	V
FRACTIONS: WHOLE NUMBER X FRACTION (O 8)	.23046	.49764	.21233	.15446	.10809
INTEGERS: LOCATE INTEGERS ON A NUMBER LINE (O 16)	.16615	.48817	.07674	.27785	.34725
ALGEBRA: SOLVE LINEAR EQUATION (O 35)	.10594	.47668	.17249	.22973	.23323
PROB & STAT: FIND THE MEAN OF A SET OF NUMBERS (O 40)*	.13896	.44965	.15676	.19107	.20797
FRACTIONS: WHOLE NUMBER X MIXED NUMBER (O 9)*	.27943	.44681	.18075	.27446	-.04458
DECIMALS: DECIMAL DIVIDED BY DECIMAL (O 15)*	.27088	.43991	.39219	.17599	.02262
INTEGERS: ADD INTEGERS (O 17)	.26684	.43870	.10029	.39430	.22406
ALGEBRA: WRITE R**N AS N FACTORS OF R (O 36)	.16508	.39130	.35132	.08003	.23012
DECIMALS: ROUND TO NEAREST 1, .1, .01 (O 10)	.22900	.36429	.19264	.27599	.33719
NON-GEOM MEAS: MULTIPLY/DIVIDE MONEY BY POS INTEGER (O 32)	.23137	.21318	.74306	-.04296	.11656
GEOM MEAS: READ A COORDINATE SYSTEM (O 26)*	.15811	.11388	.70933	.08808	.19083
RATIO PROP %: WRITE RATIO DESCRIBING INDICATED COMPARISON (O 18)	.22173	.07539	.69274	.09157	.10496
GEOM MEAS: LOCATE ITEMS IN A TABLE OF DATA (O 27)	.54018	.05343	.57363	-.00574	.25972
DECIMALS: ORDER A SET OF DECIMALS (O 12)*	.27440	.16279	.55408	.26866	.11957
RATIO PROP %: CONVERT FRACTIONS DECIMALS PERCENTS (O 20)*	.29470	.26860	.54195	.28509	.05550
PROB & STAT: PREDICT NUMBER OF TIMES EVENT WILL OCCUR (O 39)	.21977	.29015	.54053	.41328	.12329
RATIO PROP %: WORD PROBLEM--FIND PERCENTAGE OF A NUMBER (O 22)*	.32283	.24770	.50762	.35391	.05041

TABLE C-2--Continued

Objectives	Factors**				
	I	II	III	IV	V
GEOM MEAS: FIND PERIMETER OF POLYGONS AND CIRCLES (O 24)	.31492	.38330	.30115	.52220	.08194
RATIO PROP %: WRITE EQUIVALENT RATIO--SUPPLY WHOLE NUMBER (O 19)	.20890	.29205	.07147	.48578	.10894
GEOM MEAS: MEASURE OBJECT TO NEAREST UNIT (O 23)	.16129	.36502	.06500	.46138	.18586
GEOM MEAS: MEASURE TRIANGLE & FIND AREA (O 28)	.33782	.34745	.06337	.36761	-.02210
GEOMETRY: IDENTIFY CONGRUENT & NON-CONGRUENT FIGURES (O 34)	.10765	.14764	.34916	.14909	.52069
NON-GEOM MEAS: FIND DIFFERENCE IN TIME INTERVALS (O 30)	.13406	.36188	.31931	.25206	.42660
FRACTIONS: MULTIPLY FRACTIONS (O 7)*	.15571	.19187	.38261	-.05730	.39835

*These objectives appeared on both forms.

**Objectives are arranged according to factor loadings. The highest factor loading for each objective is contained in a rectangle.

TABLE C-3

PEARSON PRODUCT-MOMENT CORRELATION COEFFICIENTS AMONG FACTOR SCORES FROM THE OLD (1979) AND NEW (1980) GRADE 10 MEAP MATHEMATICS TESTS (N = 557)

	Factors							
	(New I)	(New II)	(New III)	(Old I)	(Old II)	(Old III)	(Old IV)	(Old V)
Fractions, Algebraic Operations and Formulas (New I)	1.0000 P=*****	0.1399 P=0.000	0.1558 P=0.000	0.3214 P=0.000	0.6460 P=0.000	0.0798 P=0.030	0.4102 P=0.000	0.0534 P=0.104
Decimals (New II)	0.1399 P=0.000	1.0000 P=*****	0.2111 P=0.000	0.2944 P=0.000	0.2234 P=0.000	0.2792 P=0.000	0.1443 P=0.000	0.0885 P=0.018
Division (New III)	0.1558 P=0.000	0.2111 P=0.000	1.0000 P=*****	0.1847 P=0.000	0.3854 P=0.000	0.1717 P=0.000	0.1871 P=0.000	0.3096 P=0.000
Whole No. & Decimal Multiplication and Division (Old I)	0.3214 P=0.000	0.2944 P=0.000	0.1847 P=0.000	1.0000 P=*****	0.0676 P=0.055	0.0942 P=0.013	0.0627 P=0.070	0.0177 P=0.338
Algebraic Operations & Fractions (Old II)	0.6460 P=0.000	0.2234 P=0.000	0.3854 P=0.000	0.0676 P=0.055	1.0000 P=*****	0.0197 P=0.322	0.1421 P=0.000	0.0749 P=0.039
Ratio, Proportion, Percent and Probability (Old III)	0.0798 P=0.030	0.2792 P=0.000	0.1717 P=0.000	0.0942 P=0.013	0.0197 P=0.322	1.0000 P=*****	-0.0010 P=0.490	0.1087 P=0.005
Metric Measurement (Old IV)	0.4102 P=0.000	0.1443 P=0.000	0.1871 P=0.000	0.0627 P=0.070	0.1421 P=0.000	-0.0010 P=0.490	1.0000 P=*****	0.0501 P=0.119
Non-Metric Measurement (Old V)	0.0534 P=0.104	0.0885 P=0.018	0.3096 P=0.000	0.0177 P=0.338	0.0749 P=0.039	0.1087 P=0.005	0.0501 P=0.119	1.0000 P=*****

TABLE C-4

ROTATED FACTOR MATRIX: ALL OBJECTIVES
NEW (1980) AND OLD (1979) GRADE 10 MEAP MATHEMATICS TESTS

Objectives	Factors**								
	I	II	III	IV	V	VI	VII	VIII	IX
WHOLE NUMBER DIVISION: COMPUTATION (N 1)	.67280	.15542	.15624	.10194	.14446	-.02269	.06568	.00365	.17640
WHOLE NUMBER DIVISION: WORD PROBLEMS (N 2)	.64044	.19519	.11928	.32267	.15157	.05699	.02245	-.05603	.14796
FRACTIONS: MULTIPLY FRACTIONS (N 15)*	.62880	.22054	.09021	-.01855	.06969	.10256	-.02162	.35020	-.06620
DECIMALS: DECIMAL X DECIMAL (N 5)*	.62800	.13804	.12819	.17243	.16691	.07045	.20432	.09890	.17162
DECIMALS: WORD PROBLEMS, MULTIPLICATION (N 6)	.62243	.16448	.08891	.16649	.22207	.19442	.02301	.15807	-.04171
DECIMALS: ORDER SET OF DECIMALS (N 4)*	.57667	.16629	.11645	.10122	.07085	.17745	.02688	-.04059	-.19979
PROB & STAT: FIND THE MEAN OF A SET OF NUMBERS (N 26)*	.57592	.09853	.13418	.20405	.14366	.19273	.19422	-.00953	-.01856
EQUATIONS EXP GRAPHS: READ A COORDINATE SYSTEM (N 28)*	.56010	.17556	.08857	.11853	.12380	.09554	-.08340	-.24261	.13824
DECIMALS: DECIMAL DIVIDED BY WHOLE NUMBER (N 7)	.55029	.14103	.20069	.16981	.32822	.17071	.17157	.02832	-.07504
RATIO PROP %: WORD PROBLEM--FIND PERCENTAGE OF A NUMBER (N 18)*	.54166	.12543	.25387	.17810	.16810	.27933	.05306	.01125	-.22396
NON-METRIC MEAS: MONEY WORD PROBLEMS (N 23)	.52457	.17704	.17536	.08220	.20789	.09643	.18423	-.04569	-.17232
PROB & STAT: PROBABILITY OF A SIMPLE EVENT (N 25)	.50349	.12228	.11201	.24696	.13896	.34618	-.02001	-.04232	-.07434
NON-METRIC MEAS: TIME CONVERSION (N 22)	.50310	.13196	.17083	.44821	.20811	.08792	-.11215	-.14469	.07528
EQUATIONS EXP GRAPHS: EVALUATE COMMON ALG EXP (N 27)*	.49003	.10903	.25927	.44625	.23426	.25408	.07401	.06124	-.11045
FRACTIONS: CONVERT MIXED NOS. TO COMMON FRACTIONS (N 10)	.47222	.21078	.19223	.15899	.33752	.20298	-.07020	.13130	-.05046
DECIMALS: CONVERT FRACTIONS TO DECIMALS (N 3)	.44069	.13435	.15597	.41408	.27888	.28315	-.05264	-.07006	.20233

TABLE C-4--Continued

Objectives	Factors**								
	I	II	III	IV	V	VI	VII	VIII	IX
FRACTIONS: FIND THE LARGER OF TWO FRACTIONS (N 9)*	.44018	.10060	.16684	.34441	.28180	.16076	-.07778	-.06440	.00590
RATIO PROP %: CONVERT FRACTIONS DECIMALS PERCENTS (N 17)*	.40616	.15550	.07963	.21671	.18159	.22536	.06138	-.10199	.25762
DECIMALS: DECIMAL DIVIDED BY DECIMAL (N 8)*	.39479	.13946	.07437	.14405	.22043	.18843	.30632	.00321	.01698
METRIC MEAS: VOLUME COMPUTATION (N 20)	.38895	.10763	.17057	.31236	.20197	.31278	.02503	-.02791	.16420
GEOM MEAS: READ A COORDINATE SYSTEM (O 26)*	.16116	.74405	.10846	.07608	.07577	.05690	.02597	-.09486	.01314
NON-GEOM MEAS: MULTIPLY/DIVIDE MONEY BY POS INTEGER (O 32)	.15420	.73171	.20062	.03117	.15784	.00608	.13712	.06184	.01328
RATIO PROP %: WRITE RATIO DESCRIBING INDICATED COMPARISON (O 18)	.10272	.69583	.17493	.02789	.06159	.11068	.07531	.00389	-.00118
GEOM MEAS: LOCATE ITEMS IN A TABLE OF DATA (O 27)	.17340	.63251	.49451	.05417	.05138	.04698	-.08997	.12173	-.00708
DECIMALS: ORDER A SET OF DECIMALS (O 12)*	.15938	.57185	.23672	.17687	.06593	.19669	.08444	-.09234	-.11596
PROB & STAT: PREDICT NUMBER OF TIMES EVENT WILL OCCUR (O 39)	.16002	.54543	.20635	.32951	.16104	.23071	.10480	-.16824	-.03405
RATIO PROP %: CONVERT FRACTIONS DECIMALS PERCENTS (O 20)*	.18602	.54080	.24202	.18723	.16025	.24884	.12164	-.13018	.16759
FRACTIONS: MULTIPLY FRACTIONS (O 7)*	.12309	.47826	.09917	.19274	.11177	-.00681	-.05862	.25722	.00391
GEOMETRY: IDENTIFY CONGRUENT & NON-CONGRUENT FIGURES (O 34)	.15013	.47593	.05780	.31285	.09071	.05215	-.16031	.04241	.04168
RATIO PROP %: WORD PROBLEM—FIND PERCENTAGE OF A NUMBER (O 22)*	.17433	.47570	.30752	.26381	.09407	.25385	.16888	-.06290	-.03752
ALGEBRA: WRITE R**N AS N FACTORS OF R (O 36)	.18563	.36904	.13495	.34233	.17126	.06527	.13391	.19424	.05240
DECIMALS: DECIMAL X DECIMAL (O 14)*	.24411	.29246	.65753	.10563	.16415	.10599	.20048	.03093	.03662

TABLE C-4--Continued

Objectives	Factors**								
	I	II	III	IV	V	VI	VII	VIII	IX
PROB & STAT: ANSWER QUESTIONS USING BAR GRAPH (O 38)	.20778	.29779	.65620	.23010	.12325	.16671	-.05407	-.06185	-.01903
GEOM MEAS: WORD PROBLEM--STANDARD UNITS OF MEASURE (O 25)	.17286	.25435	.60836	.22575	.22365	.31768	.05153	-.12366	-.05249
NON-GEOM MEAS: GIVEN COST, WHAT COULD BE PURCHASED (O 31)	.18670	.49264	.60719	.14777	.07676	.07008	.00458	.09201	-.00684
WHOLE NUMBER DIVISION: COMPUTATION (O 1)	.20127	.44471	.60003	.12752	.20329	.08651	.18194	.13124	.08380
FRACTIONS: FIND THE LARGER OF TWO FRACTIONS (O 3)*	.19968	.22277	.55682	.28573	.23985	.26057	-.08175	-.11283	-.03634
DECIMALS: CONVERT COMMON FRACTION TO DECIMAL (O 11)	.21736	.16058	.50202	.29060	.19842	.39203	.13037	-.06294	.11403
RATIO PROP %: DETERMINE PERCENTAGE OF GIVEN NUMBER (O 21)	.15420	.26800	.47289	.15441	.12375	.30827	.11872	.03295	-.06965
GEOMETRY: PARTS OF A CIRCLE (O 33)*	.18973	.36175	.42372	.15028	.07806	.40611	-.00208	.08570	.06216
FRACTIONS: FIND A SET OF EQUIVALENT FRACTIONS (O 2)	.18580	.38455	.38796	.19324	.26024	.25958	.14082	-.00446	-.01604
ALGEBRA: EVALUATE COMMON ALG EXP (O 37)*	.25879	.14378	.24782	.61620	.22704	.26380	.13725	.13580	-.01939
INTEGERS: LOCATE INTEGERS ON A NUMBER LINE (O 16)	.16807	.15442	.15283	.54874	.29970	.09402	.00729	-.02308	.05207
ALGEBRA: SOLVE LINEAR EQUATION (O 35)	.23158	.17868	.10260	.51505	.16890	.08373	.15526	.14996	-.02293
NON-GEOM MEAS: FIND DIFFERENCE IN TIME INTERVALS (O 30)	.18143	.40223	.10782	.49118	.19057	.08083	.00859	-.07145	-.04573
INTEGERS: ADD INTEGERS (O 17)	.21778	.13942	.23046	.49061	.21326	.27487	.06062	.02793	-.05530
DECIMALS: ROUND TO NEAREST 1, .1, .01 (O 10)	.15830	.27199	.19008	.44596	.17916	.16824	.04697	.00047	.10644
GEOM MEAS: MEASURE OBJECT TO NEAREST UNIT (O 23)	.19587	.10690	.12253	.44488	.22328	.27776	.00231	-.16640	-.05759

TABLE C-4--Continued

Objectives	Factors**								
	I	II	III	IV	V	VI	VII	VIII	IX
PROB & STAT: FIND THE MEAN OF A SET OF NUMBERS (O 40)*	.31387	.14779	.11320	.39879	.14609	.09037	.28990	.04094	.02085
RATIO PROP %: WRITE EQUIVALENT RATIO--SUPPLY WHOLE NUMBER (O 19)	.15036	.10573	.16833	.34441	.18503	.34066	.03616	-.17420	-.03472
FRACTIONS: ADD MIXED NUMBERS (O 4)	.24159	.10653	.15976	.37350	.65300	.12458	.07706	-.02734	-.00925
FRACTIONS: SUBTRACT MIXED NUMBERS UNLIKE DENOMINATORS (O 6)*	.19115	.15538	.14649	.26570	.65019	.12899	.09343	.02216	.04527
FRACTIONS: SUBTRACT FRACTIONS UNLIKE DENOMINATORS (N 13)*	.40820	.09602	.17552	.22143	.62179	.11152	-.04901	.04828	.13097
FRACTIONS: SUBTRACT MIXED NUMBERS UNLIKE DENOMINATORS (N 14)*	.40805	.16961	.17334	.19910	.58084	.18696	.07616	.04592	.03435
FRACTIONS: SUBTRACT FRACTIONS UNLIKE DENOMINATORS (O 5)*	.20992	.30689	.47566	.19586	.54822	.13438	.04203	.08588	.09537
FRACTIONS: ADDITION WORD PROBLEMS (N 12)	.29873	.13254	.07057	.18971	.53986	.27237	.01885	-.07786	-.14318
FRACTIONS: ADD FRACTIONS WITH UNLIKE DENOMINATORS (N 11)	.31459	.09996	.10770	.21573	.53075	.28450	.04657	-.01665	-.02830
FRACTIONS: WHOLE NUMBER X MIXED NUMBER (O 9)*	.14025	.17985	.19967	.19003	.38638	.32469	.17327	-.06209	-.01667
FRACTIONS: WHOLE NUMBER X MIXED NUMBER (N 16)*	.23672	.10994	.11007	.12029	.37175	.33162	.13726	-.02873	-.03459
FRACTIONS: WHOLE NUMBER X FRACTION (O 8)	.18635	.22997	.17504	.29009	.32077	.20256	.12532	.16506	.11316
DECIMALS: DECIMAL X WHOLE NO. POWER OF 10 (O 13)	.20579	.31282	.19385	.27613	.31664	.17257	.31348	.03789	-.01438
METRIC MEAS: AREA WORD PROBLEMS (N 19)	.30628	.13597	.16399	.09748	.17376	.60443	.02737	.03455	.03405
GEOM MEAS: WORD PROBLEM--RECTANGLES, TRIANGLES, CIRCLES (O 29)	.14736	.20054	.40132	.21624	.22163	.51670	-.01521	.05670	.04657
GEOM MEAS: MEASURE TRIANGLE AND FIND AREA (O 28)	.13330	.06799	.22326	.20008	.24347	.51569	.13426	.05324	.00973

TABLE C-4--Continued

Objectives	Factors**								
	I	II	III	IV	V	VI	VII	VIII	IX
GEOM MEAS: FIND PERIMETER OF POLYGONS & CIRCLES (O 24)	.19133	.30991	.27209	.38502	.22688	.38756	.11434	-.14818	-.06846
GEOMETRY: PARTS OF A CIRCLE (N 24)*	.32846	.02051	.11468	.17889	.13448	.38035	-.02201	.06868	.07802
NON-METRIC MEAS: ANGLE MEASUREMENT (N 21)	.34927	.10990	.11251	.09624	.17279	.36560	.02351	-.06876	-.13537
DECIMALS: DECIMAL DIVIDED BY DECIMAL (O 15)*	.24644	.35240	.24040	.20460	.24496	.13209	.44589	-.04540	.00217

*These objectives appeared on both forms.

**Objectives are arranged according to factor loadings. The highest factor loading for each objective is contained in a rectangle.

TABLE C-5

ROTATED FACTOR MATRIX
14 PAIRS OF COMMON OBJECTIVES
OLD (1979) AND NEW (1980) GRADE 10 MEAP MATHEMATICS TESTS
NO RECODING

Objectives	Factors*			
	I	II	III	IV
DECIMALS: DECIMAL X DECIMAL (N 5)	.64736	.20398	.24220	.07079
PROB & STAT: FIND THE MEAN OF A SET OF NUMBERS (N 26)	.62701	.13917	.23461	.20182
FRACTIONS: MULTIPLY FRACTIONS (N 15)	.58972	.17308	.11698	.07577
DECIMALS: ORDER SET OF DECIMALS (N 4)	.57006	.21158	.08871	.18520
EQUATIONS EXP GRAPHS: READ A COORDINATE SYSTEM (N 28)	.51329	.20472	.16664	.09031
RATIO PROP %: WORD PROBLEM--FIND PERCENTAGE OF A NUMBER (N 18)	.51058	.20977	.21451	.37297
DECIMALS: DECIMAL DIVIDED BY DECIMAL (N 8)	.44554	.22044	.28354	.06947
FRACTIONS: FIND THE LARGER OF TWO FRACTIONS (N 9)	.43818	.14868	.32986	.33299
RATIO PROP %: CONVERT FRACTIONS DECIMALS PERCENTS (N 17)	.42557	.22817	.26757	.12675
PROB & STAT: FIND THE MEAN OF A SET OF NUMBERS (O 40)	.38779	.20854	.26389	.21372
GEOMETRY: PARTS OF A CIRCLE (N 24)	.35524	.07728	.22477	.28943
GEOM MEAS: READ A COORDINATE SYSTEM (O 26)	.17417	.69462	.07186	.02423
DECIMALS: ORDER A SET OF DECIMALS (O 12)	.19058	.65931	.11343	.16981
RATIO PROP %: CONVERT FRACTIONS DECIMALS PERCENTS (O 20)	.19117	.63974	.27862	.14927
RATIO PROP %: WORD PROBLEM--FIND PERCENTAGE OF A NUMBER (O 22)	.19355	.59594	.17065	.34477
DECIMALS: DECIMAL X DECIMAL (O 14)	.22071	.46340	.28324	.36030
DECIMALS: DECIMAL DIVIDED BY DECIMAL (O 15)	.31108	.45650	.31930	.16684
GEOMETRY: PARTS OF A CIRCLE (O 33)	.19364	.45346	.19956	.42472

TABLE C-5--Continued

Objectives	Factors*			
	I	II	III	IV
FRACTIONS: MULTIPLY FRACTIONS (O 7)	.19279	$\boxed{.40383}$	.13747	.01829
FRACTIONS: SUBTRACT MIXED NUMBERS UNLIKE DENOMINATORS (O 6)	.19637	.19991	$\boxed{.72769}$	.10946
FRACTIONS: SUBTRACT MIXED NUMBERS UNLIKE DENOMINATORS (N 14)	.39635	.20693	$\boxed{.66104}$	.15731
FRACTIONS: SUBTRACT FRACTIONS UNLIKE DENOMINATORS (N 13)	.37470	.12110	$\boxed{.65829}$	.18651
FRACTIONS: SUBTRACT FRACTIONS UNLIKE DENOMINATORS (O 5)	.18282	.43202	$\boxed{.61418}$	.26296
FRACTIONS: WHOLE NUMBER X MIXED NUMBER (O 9)	.18669	.24146	$\boxed{.44996}$	.25639
FRACTIONS: WHOLE NUMBER X MIXED NUMBER (N 16)	.26585	.15455	$\boxed{.40811}$	.21001
EQUATIONS EXP GRAPHS: EVALUATE COMMON ALG EXP (N 27)	.48845	.18718	.34264	$\boxed{.52288}$
FRACTIONS: FIND THE LARGER OF TWO FRACTIONS (O 3)	.18757	.40688	.32436	$\boxed{.48184}$
ALGEBRA: EVALUATE COMMON ALG EXP (O 37)	.32387	.25711	.38267	$\boxed{.46951}$

*Objectives are arranged according to factor loadings. The highest factor loading for each objective is contained in a rectangle.

TABLE C-6

ROTATED FACTOR MATRIX
40 OBJECTIVES NOT COMMON TO THE
OLD (1979) AND NEW (1980) GRADE 10 MEAP MATHEMATICS TESTS
NO RECODING

Objectives	Factors*					
	I	II	III	IV	V	VI
WHOLE NUMBER DIVISION: WORD PROBLEMS (N 2)	.68685	.34709	.11964	.16503	.12551	-.06211
WHOLE NUMBER DIVISION: COMPUTATION (N 1)	.68205	.13068	.07080	.17318	.12537	-.01354
DECIMALS: WORD PROBLEMS, MULTIPLICATION (N 6)	.61227	.18477	.23531	.14173	.11525	.14402
DECIMALS: DECIMAL DIVIDED BY WHOLE NUMBER (N 7)	.58051	.17387	.30836	.15869	.17558	.25250
NON-METRIC MEAS: TIME CONVERSION (N 22)	.51264	.49700	.18256	.08798	.15169	-.10050
NON-METRIC MEAS: MONEY WORD PROBLEMS (N 23)	.50596	.10199	.23994	.20171	.13760	.10461
FRACTIONS: CONVERT MIXED NOS. TO COMMON FRACTIONS (N 10)	.50267	.19990	.26557	.18614	.20505	.18847
PROB & STAT: PROBABILITY OF A SIMPLE EVENT (N 25)	.48140	.22705	.40059	.08640	.13489	-.01402
METRIC MEAS: VOLUME COMPUTATION (N 20)	.40892	.32759	.30146	.06875	.21722	.07740
INTEGERS: LOCATE INTEGERS ON A NUMBER LINE (O 16)	.18847	.59574	.17757	.11068	.15332	.18099
NON-GEOM MEAS: FIND DIFFERENCE IN TIME INTERVALS (O 30)	.19411	.55377	.14870	.35018	.12774	-.01282
INTEGERS: ADD INTEGERS (O 17)	.19416	.49407	.32382	.12040	.23040	.12837
DECIMALS: ROUND TO NEAREST 1, .1, .01 (O 10)	.19091	.48983	.16920	.19663	.26357	.00788
ALGEBRA: SOLVE LINEAR EQUATION (O 35)	.25427	.48333	.11323	.15746	.11271	.22114
GEOM MEAS: MEASURE OBJECT TO NEAREST UNIT (O 23)	.16935	.47519	.38912	.04871	.12839	-.00830
DECIMALS: CONVERT FRACTIONS TO DECIMALS (N 3)	.44033	.45950	.31570	.06006	.21010	.05128
FRACTIONS: ADD MIXED NUMBERS (O 4)	.32040	.45212	.35193	.09591	.12138	.33883

TABLE C-6--Continued

Objectives	Factors*					
	I	II	III	IV	V	VI
FRACTIONS: WHOLE NUMBER X FRACTION (O 8)	.24023	.34774	.20411	.18088	.22544	.28382
ALGEBRA: WRITE R**N AS N FACTORS OF R (O 36)	.21514	.34605	.08349	.34034	.16553	.20327
METRIC MEAS: AREA WORD PROBLEMS (N 19)	.28772	.10913	.58736	.08750	.22836	.02058
GEOM MEAS: MEASURE TRIANGLE & FIND AREA (O 28)	.12417	.18802	.54877	.04774	.27367	.13628
GEOM MEAS: WORD PROBLEM--RECTANGLES, TRIANGLES, CIRCLES (O 29)	.14974	.21809	.50424	.17709	.43852	.08746
GEOM MEAS: FIND PERIMETER OF POLYGONS & CIRCLES (O 24)	.15939	.43104	.47512	.28354	.25725	.02970
NON-METRIC MEAS: ANGLE MEASUREMENT (N 21)	.27900	.10988	.47275	.13879	.07358	.01012
FRACTIONS: ADDITION WORD PROBLEMS (N 12)	.31806	.27677	.46699	.12623	.03116	.26508
FRACTIONS: ADD FRACTIONS WITH UNLIKE DENOMINATORS (N 11)	.35581	.28470	.45778	.09872	.07688	.26706
RATIO PROP %: WRITE EQUIVALENT RATIO--SUPPLY WHOLE NUMBER (O 19)	.15331	.36222	.43425	.09093	.14845	-.07378
NON-GEOM MEAS: MULTIPLY/DIVIDE MONEY BY POS INTEGER (O 32)	.16215	.10569	.07117	.74494	.17371	.16331
RATIO PROP %: WRITE RATIO DESCRIBING INDICATED COMPARISON (O 18)	.10533	.09866	.12197	.68097	.16831	.03459
GEOM MEAS: LOCATE ITEMS IN A TABLE OF DATA (O 27)	.18354	.09831	.05354	.63174	.47055	-.02533
PROB & STAT: PREDICT NUMBER OF TIMES EVENT WILL OCCUR (O 39)	.16545	.38000	.30924	.49988	.20044	-.01392
GEOMETRY: IDENTIFY CONGRUENT & NON-CONGRUENT FIGURES (O 34)	.14794	.38177	.09139	.41767	.07694	-.11596
DECIMALS: DECIMAL X WHOLE NO. POWER OF 10 (O 13)	.19812	.31489	.28178	.32266	.19276	.30103

TABLE C-6--Continued

Objectives	Factors*					
	I	II	III	IV	V	VI
PROB & STAT: ANSWER QUESTIONS USING BAR GRAPH (O 38)	.19400	.24281	.23217	.29345	.62985	-.04178
NON-GEOM MEAS: GIVEN COST, WHAT COULD BE PURCHASED (O 31)	.21220	.15935	.07448	.50822	.60524	.01444
WHOLE NUMBER DIVISION: COMPUTATION (O 1)	.23858	.17757	.10705	.45977	.59960	.20398
DECIMALS: CONVERT COMMON FRACTION TO DECIMAL (O 11)	.21627	.31888	.38998	.10326	.55483	.08165
GEOM MEAS: WORD PROBLEM--STANDARD UNITS OF MEASURE (O 25)	.18420	.24259	.43139	.25766	.55236	.02432
RATIO PROP %: DETERMINE PERCENTAGE OF GIVEN NUMBER (O 21)	.11935	.16735	.31000	.25020	.50807	.10222
FRACTIONS: FIND A SET OF EQUIVALENT FRACTIONS (O 2)	.21115	.23506	.32699	.37714	.39059	.14647

*Objectives are arranged according to factor loadings. The highest factor loading for each objective is contained in a rectangle.

TABLE C-7

PEARSON PRODUCT-MOMENT CORRELATION COEFFICIENTS AMONG FACTOR SCORES FROM THE 14 PAIRS OF COMMON OBJECTIVES AND 40 OBJECTIVES NOT COMMON TO THE OLD (1979) AND NEW (1980) GRADE 10 MEAP MATHEMATICS TESTS (N = 557)

Objectives	14 Pairs Of Common Objectives				40 Objectives Not Common					
	Factor I	Factor II	Factor III	Factor IV	Factor I	Factor II	Factor III	Factor IV	Factor V	Factor VI
14 Common										
Factor I	1.0000	0.0583	0.1216	0.1427	0.7527	0.1999	0.2439	0.0636	0.0168	0.0539
	P=*****	P=0.085	P=0.002	P=0.000	P=0.000	P=0.000	P=0.000	P=0.067	P=0.346	P=0.102
Factor II	0.0583	1.0000	0.0714	0.1386	0.0463	0.1937	0.1606	0.7483	0.4245	0.0238
	P=0.085	P=*****	P=0.046	P=0.001	P=0.137	P=0.000	P=0.000	P=0.000	P=0.000	P=0.288
Factor III	0.1216	0.0714	1.0000	0.1283	0.2825	0.4139	0.3624	0.0414	0.1664	0.4471
	P=0.002	P=0.046	P=*****	P=0.001	P=0.000	P=0.000	P=0.000	P=0.165	P=0.000	P=0.000
Factor IV	0.1427	0.1386	0.1283	1.0000	0.1373	0.3340	0.4146	0.0093	0.4855	0.0051
	P=0.000	P=0.001	P=0.001	P=*****	P=0.001	P=0.000	P=0.000	P=0.413	P=0.000	P=0.452
40 Not Common										
Factor I	0.7527	0.0463	0.2825	0.1373	1.0000	0.1086	0.0816	0.0377	0.0126	0.0434
	P=0.000	P=0.137	P=0.000	P=0.001	P=*****	P=0.005	P=0.027	P=0.187	P=0.383	P=0.153
Factor II	0.1999	0.1937	0.4139	0.3340	0.1086	1.0000	0.1422	0.0495	0.0292	0.0347
	P=0.000	P=0.000	P=0.000	P=0.000	P=0.005	P=*****	P=0.000	P=0.122	P=0.246	P=0.207
Factor III	0.2439	0.1606	0.3624	0.4146	0.0816	0.1422	1.0000	-0.0404	0.1166	0.1009
	P=0.000	P=0.000	P=0.000	P=0.000	P=0.027	P=0.000	P=*****	P=0.171	P=0.003	P=0.009
Factor IV	0.0636	0.7483	0.0414	0.0093	0.0377	0.0495	-0.0404	1.0000	0.1631	0.0446
	P=0.067	P=0.000	P=0.165	P=0.413	P=0.187	P=0.122	P=0.171	P=*****	P=0.000	P=0.147
Factor V	0.0168	0.4245	0.1664	0.4855	0.0126	0.0292	0.1166	0.1631	1.0000	-0.0115
	P=0.346	P=0.000	P=0.000	P=0.000	P=0.383	P=0.246	P=0.003	P=0.000	P=*****	P=0.393
Factor VI	0.0539	0.0238	0.4471	0.0051	0.0434	0.0347	0.1009	0.0446	-0.0115	1.0000
	P=0.102	P=0.288	P=0.000	P=0.452	P=0.153	P=0.207	P=0.009	P=0.147	P=0.393	P=*****

TABLE C-8

ROTATED FACTOR MATRIX
14 PAIRS OF COMMON OBJECTIVES
OLD (1979) AND NEW (1980) GRADE 10 MEAP MATHEMATICS TESTS
OLD TEST SCORES RECODED* NEW TEST SCORES UNCHANGED

Objectives	Factors**				
	I	II	III	IV	V
FRACTIONS: MULTIPLY FRACTIONS (N 15)	.60896	.12043	.14741	.07914	.11603
DECIMALS: DECIMAL X DECIMAL (N 5)	.60163	.18385	.19041	.09348	.30539
DECIMALS: ORDER SET OF DECIMALS (N 4)	.55843	.07005	.22037	.21849	.10771
PROB & STAT: FIND THE MEAN OF A SET OF NUMBERS (N 26)	.54670	.17364	.09569	.23893	.35560
EQUATIONS EXP GRAPHS: READ A COORDINATE SYSTEM (N 28)	.53216	.17693	.21594	.12371	.03916
RATIO PROP %: WORD PROBLEM--FIND PERCENTAGE OF A NUMBER (N 18)	.48181	.18893	.21779	.38669	.15330
FRACTIONS: FIND THE LARGER OF TWO FRACTIONS (N 9)	.41837	.30985	.14903	.41038	.09058
RATIO PROP %: CONVERT FRACTIONS DECIMALS PERCENTS (N 17)	.38935	.23691	.23229	.17044	.17144
FRACTIONS: SUBTRACT FRACTIONS UNLIKE DENOMINATORS (N 13)	.37475	.68474	.12870	.23675	.09311
FRACTIONS: SUBTRACT MIXED NUMBERS UNLIKE DENOMINATORS (N 14)	.36114	.64481	.21270	.20113	.21678
FRACTIONS: SUBTRACT MIXED NUMBERS UNLIKE DENOMINATORS (O 6)	.13415	.64445	.20666	.17014	.24650
FRACTIONS: SUBTRACT FRACTIONS UNLIKE DENOMINATORS (O 5)	.15733	.58879	.41510	.26626	.19844
FRACTIONS: WHOLE NUMBER X MIXED NUMBER (O 9)	.09886	.37400	.22760	.27867	.36977
FRACTIONS: WHOLE NUMBER X MIXED NUMBER (N 16)	.18520	.34222	.14156	.22692	.32710
DECIMALS: ORDER A SET OF DECIMALS (O 12)	.15692	.08280	.59321	.19263	.15949

TABLE C-8--Continued

Objectives	Factors**				
	I	II	III	IV	V
GEOM MEAS: READ A COORDINATE SYSTEM (O 26)	.19882	.08622	.59164	.03799	.07192
RATIO PROP %: CONVERT FRACTIONS DECIMALS PERCENTS (O 20)	.13390	.24584	.57851	.18514	.20083
RATIO PROP %: WORD PROBLEM---FIND PERCENTAGE OF A NUMBER (O 22)	.14119	.13829	.50943	.36030	.20540
DECIMALS: DECIMAL X DECIMAL (O 14)	.20089	.21994	.40563	.29822	.27874
FRACTIONS: MULTIPLY FRACTIONS (O 7)	.20423	.14664	.34409	.03832	.04692
EQUATIONS EXP GRAPHS: EVALUATE COMMON ALG EXP (N 27)	.41344	.27011	.18364	.54872	.28716
ALGEBRA: EVALUATE COMMON ALG EXP (O 37)	.22240	.28066	.23052	.53255	.34520
FRACTIONS: FIND THE LARGER OF TWO FRACTIONS (O 3)	.18013	.31555	.34394	.49935	.10428
GEOMETRY: PARTS OF A CIRCLE (O 33)	.18244	.17962	.37490	.42990	.13289
GEOMETRY: PARTS OF A CIRCLE (N 24)	.31720	.19843	.08209	.34166	.12073
DECIMALS: DECIMAL DIVIDED BY DECIMAL (O 15)	.16015	.21819	.37008	.16837	.50810
DECIMALS: DECIMAL DIVIDED BY DECIMAL (N 8)	.34813	.18626	.19639	.06341	.47508
PROB & STAT: FIND THE MEAN OF A SET OF NUMBERS (O 40)	.26697	.17355	.15238	.24762	.44574

*Old test scores were recoded as follows: 0=0 1=0 2=1 3=2 4=3.

**Objectives are arranged according to factor loadings. The highest factor loading for each objective is contained in a rectangle.

TABLE C-9

ROTATED FACTOR MATRIX
40 OBJECTIVES NOT COMMON TO THE
OLD (1979) AND NEW (1980) GRADE 10 MEAP MATHEMATICS TESTS
OLD TEST SCORES RECODED* NEW TEST SCORES UNCHANGED

Objectives	Factors**					
	I	II	III	IV	V	VI
GEOM MEAS: WORD PROB--RECTANGLES, TRIANGLES, CIRCLES (O 29)	.64142	.17317	.19436	.17527	.10571	-.01370
GEOM MEAS: MEASURE TRIANGLE & FIND AREA (O 28)	.63712	.18364	.11184	.19091	.14742	-.04107
DECIMALS: CONVERT COMMON FRACTION TO DECIMAL (O 11)	.61186	.20740	.24168	.29699	-.02728	-.20285
GEOM MEAS: WORD PROBLEM--STANDARD UNITS OF MEASURE (O 25)	.61065	.16560	.36892	.24215	.03027	-.00169
METRIC MEAS: AREA WORD PROBLEMS (N 19)	.59721	.32926	.11220	.08251	.10589	.05700
GEOM MEAS: FIND PERIMETER OF POLYGONS & CIRCLES (O 24)	.53877	.14495	.24225	.36416	.11213	.15618
RATIO PROP %: DETERMINE PERCENTAGE OF GIVEN NUMBER (O 21)	.48401	.09806	.34307	.17978	.04166	-.10660
RATIO PROP %: WRITE EQUIVALENT RATIO--SUPPLY WHOLE NUMBER (O 19)	.46780	.16394	.11682	.31614	.04864	.21825
FRACTIONS: FIND A SET OF EQUIVALENT FRACTIONS (O 2)	.44832	.20725	.39762	.23785	.16643	-.03675
NON-METRIC MEAS: ANGLE MEASUREMENT (N 21)	.40536	.30357	.10703	.08916	.18095	.18353
FRACTIONS: ADD FRACTIONS WITH UNLIKE DENOMINATORS (N 11)	.39493	.36767	.09987	.28412	.36571	.01857
WHOLE NUMBER DIVISION: WORD PROBLEMS (N 2)	.13021	.67487	.20607	.35630	-.04578	.06458
WHOLE NUMBER DIVISION: COMPUTATION (N 1)	.06735	.66725	.23057	.14261	-.00321	.01909

TABLE C-9--Continued

Objectives	Factors**					
	I	II	III	IV	V	VI
DECIMALS: WORD PROBLEMS, MULTIPLICATION (N 6)	.20933	.62517	.17144	.18842	.14711	-.03846
DECIMALS: DECIMAL DIVIDED BY WHOLE NUMBER (N 7)	.29481	.58494	.22346	.17986	.24823	-.07370
FRACTIONS: CONVERT MIXED NOS. TO COMMON FRACTIONS (N 10)	.26902	.51320	.24572	.21165	.16807	-.05304
PROB & STAT: PROBABILITY OF A SIMPLE EVENT (N 25)	.38908	.51148	.08078	.21329	.05035	.12386
NON-METRIC MEAS: TIME CONVERSION (N 22)	.20519	.51012	.13503	.49055	-.05643	.12850
NON-METRIC MEAS: MONEY WORD PROBLEMS (N 23)	.20975	.50726	.25056	.09662	.16862	.02062
METRIC MEAS: VOLUME COMPUTATION (N 20)	.36014	.42239	.13843	.32191	.02742	-.06673
GEOM MEAS: LOCATE ITEMS IN A TABLE OF DATA (O 27)	.16589	.18992	.71427	.10696	-.05511	.05287
NON-GEOM MEAS: GIVEN COST, WHAT COULD BE PURCHASED (O 31)	.26697	.20242	.67394	.20077	-.08772	-.04868
NON-GEOM MEAS: MULTIPLY/DIVIDE MONEY BY POS INTEGER (O 32)	.04306	.15938	.66266	.12189	.21241	.03542
WHOLE NUMBER DIVISION: COMPUTATION (O 1)	.31027	.21809	.64525	.19808	.06369	-.21483
RATIO PROP %: WRITE RATIO DESCRIBING INDICATED COMPARISON (O 18)	.11239	.11147	.58617	.10796	.09979	.10948
PROB & STAT: ANSWER QUESTIONS USING BAR GRAPH (O 38)	.45204	.19781	.46842	.23755	-.11204	-.06153
PROB & STAT: PREDICT NUMBER OF TIMES EVENT WILL OCCUR (O 39)	.32403	.18163	.40599	.39261	.09736	.19797
DECIMALS: DECIMAL X WHOLE NO. POWER OF 10 (O 13)	.30240	.18600	.35554	.31283	.30023	-.04828

TABLE C-9--Continued

Objectives	Factors**					
	I	II	III	IV	V	VI
ALGEBRA: WRITE R**N AS N FACTORS OF R (O 36)	.12230	.21022	.35375	.35081	.12296	-.08409
INTEGERS: LOCATE INTEGERS ON A NUMBER LINE (O 16)	.20665	.20636	.13404	.62003	.15991	-.01965
NON-GEOM MEAS: FIND DIFFERENCE IN TIME INTERVALS (O 30)	.20662	.18655	.28509	.52453	.04384	.12887
ALGEBRA: SOLVE LINEAR EQUATION (O 35)	.14979	.24113	.20272	.51206	.14102	-.08898
INTEGERS: ADD INTEGERS (O 17)	.40282	.19765	.18226	.50250	.09824	-.00875
DECIMALS: CONVERT FRACTIONS TO DECIMALS (N 3)	.37150	.45486	.11465	.46389	.00769	-.03528
DECIMALS: ROUND TO NEAREST 1, .1, .01 (O 10)	.30707	.17813	.23659	.45411	-.01660	-.05294
FRACTIONS: ADD MIXED NUMBERS (O 4)	.32264	.30885	.14528	.44556	.39592	-.04892
GEOM MEAS: MEASURE OBJECT TO NEAREST UNIT (O 23)	.40817	.18399	.05850	.44082	.09699	.13235
FRACTIONS: WHOLE NUMBER X FRACTION (O 8)	.26831	.23070	.27243	.36615	.18061	-.19956
GEOMETRY: IDENTIFY CONGRUENT & NON-CONGRUENT FIGURES (O 34)	.08819	.16437	.32115	.35294	-.00568	.24938
FRACTIONS: ADDITION WORD PROBLEMS (N 12)	.36674	.33222	.09023	.27920	.42617	.08096

*Old test scores were recoded as follows: 0=0 1=0 2=1 3=2 4=3.

**Objectives are arranged according to factor loadings. The highest factor loading for each objective is contained in a rectangle.

TABLE C-10

PEARSON PRODUCT-MOMENT CORRELATION COEFFICIENTS AMONG FACTOR SCORES FROM THE 14 PAIRS OF COMMON OBJECTIVES AND 40 OBJECTIVES NOT COMMON TO THE OLD* (1979) AND NEW (1980) GRADE 10 MEAP MATHEMATICS TESTS (N = 557)

Objectives	14 Pairs Of Common Objectives					40 Objectives Not Common					
	Factor I	Factor II	Factor III	Factor IV	Factor V	Factor I	Factor II	Factor III	Factor IV	Factor V	Factor VI
14 Common											
Factor I	1.0000	0.0840	0.0471	0.1300	0.1344	0.0892	0.7679	0.0801	0.1277	0.0598	0.0825
	P=*****	P=0.024	P=0.134	P=0.001	P=0.001	P=0.018	P=0.000	P=0.029	P=0.001	P=0.079	P=0.026
Factor II	0.0840	1.0000	0.0766	0.1250	0.0999	0.2774	0.2699	0.1020	0.3688	0.3955	-0.1408
	P=0.024	P=*****	P=0.035	P=0.002	P=0.009	P=0.000	P=0.000	P=0.008	P=0.000	P=0.000	P=0.000
Factor III	0.0471	0.0766	1.0000	0.1423	0.1410	0.2863	0.0619	0.6978	0.2147	0.0289	0.0790
	P=0.134	P=0.035	P=*****	P=0.000	P=0.000	P=0.000	P=0.072	P=0.000	P=0.000	P=0.248	P=0.031
Factor IV	0.1300	0.1250	0.1423	1.0000	0.1455	0.5649	0.1948	0.1208	0.4019	-0.0275	-0.0318
	P=0.001	P=0.002	P=0.000	P=*****	P=0.000	P=0.000	P=0.000	P=0.002	P=0.000	P=0.258	P=0.227
Factor V	0.1344	0.0999	0.1410	0.1455	1.0000	0.3096	0.1901	0.1807	0.2610	0.2226	-0.1368
	P=0.001	P=0.009	P=0.000	P=0.000	P=*****	P=0.000	P=0.000	P=0.000	P=0.000	P=0.000	P=0.001
40 Not Common											
Factor I	0.0892	0.2774	0.2863	0.5649	0.3096	1.0000	0.0546	0.0665	0.1219	0.0740	-0.0213
	P=0.018	P=0.000	P=0.000	P=0.000	P=0.000	P=*****	P=0.099	P=0.058	P=0.002	P=0.040	P=0.308
Factor II	0.7679	0.2699	0.0619	0.1948	0.1901	0.0546	1.0000	0.0444	0.1172	0.0636	0.0210
	P=0.000	P=0.000	P=0.072	P=0.000	P=0.000	P=0.099	P=*****	P=0.148	P=0.003	P=0.067	P=0.311
Factor III	0.0801	0.1020	0.6978	0.1208	0.1807	0.0665	0.0444	1.0000	0.0583	-0.0180	-0.0412
	P=0.029	P=0.008	P=0.000	P=0.002	P=0.000	P=0.058	P=0.148	P=*****	P=0.085	P=0.336	P=0.166
Factor IV	0.1277	0.3688	0.2147	0.4019	0.2610	0.1219	0.1172	0.0583	1.0000	0.0628	0.0531
	P=0.001	P=0.000	P=0.000	P=0.000	P=0.000	P=0.002	P=0.003	P=0.085	P=*****	P=0.069	P=0.105
Factor V	0.0598	0.3955	0.0289	-0.0275	0.2226	0.0740	0.0636	-0.0180	0.0628	1.0000	-0.0136
	P=0.079	P=0.000	P=0.248	P=0.258	P=0.000	P=0.040	P=0.067	P=0.336	P=0.069	P=*****	P=0.375
Factor VI	0.0825	-0.1408	0.0790	-0.0318	-0.1368	-0.0213	0.0210	-0.0412	0.0531	-0.0136	1.0000
	P=0.026	P=0.000	P=0.031	P=0.227	P=0.001	P=0.308	P=0.311	P=0.166	P=0.105	P=0.375	P=*****

*Old test scores were recoded as follows: 0=0 1=0 2=1 3=2 4=3.

TABLE C-11

ROTATED FACTOR MATRIX
14 PAIRS OF COMMON OBJECTIVES
OLD (1979) AND NEW (1980) GRADE 10 MEAP MATHEMATICS TESTS
OLD TEST SCORES RECODED* NEW TEST SCORES UNCHANGED

Objectives	Factors** I	II	III	IV
PROB & STAT: FIND THE MEAN OF A SET OF NUMBERS (N 26)	.65983	.14860	.24253	.06206
DECIMALS: DECIMAL X DECIMAL (N 5)	.62685	.19683	.25404	.03788
DECIMALS: ORDER SET OF DECIMALS (N 4)	.58795	.20609	.09126	.14616
FRACTIONS: MULTIPLY FRACTIONS (N 15)	.56482	.17272	.09811	.12588
EQUATIONS EXP GRAPHS: EVALUATE COMMON ALG EXP (N 27)	.56350	.16315	.37254	.37747
RATIO PROP %: WORD PROBLEM--FIND PERCENTAGE OF A NUMBER (N 18)	.55697	.18706	.22579	.31686
EQUATIONS EXP GRAPHS: READ A COORDINATE SYSTEM (N 28)	.50531	.18586	.17586	.09838
FRACTIONS: FIND THE LARGER OF TWO FRACTIONS (N 9)	.47829	.13667	.34847	.23389
DECIMALS: DECIMAL DIVIDED BY DECIMAL (N 8)	.46343	.20924	.29748	-.04519
RATIO PROP %: CONVERT FRACTIONS DECIMALS PERCENTS (N 17)	.44067	.20877	.29479	.03726
GEOMETRY: PARTS OF A CIRCLE (N 24)	.39873	.03740	.24299	.21859
PROB & STAT: FIND THE MEAN OF A SET OF NUMBERS (O 40)	.37764	.25979	.26034	.06693
GEOM MEAS: READ A COORDINATE SYSTEM (O 26)	.13326	.75052	.03046	.06896
RATIO PROP %: CONVERT FRACTIONS DECIMALS PERCENTS (O 20)	.16695	.64993	.26938	.09726
DECIMALS: ORDER A SET OF DECIMALS (O 12)	.21973	.63917	.12093	.17098
RATIO PROP %: WORD PROBLEM--FIND PERCENTAGE OF A NUMBER (O 22)	.22281	.59934	.14420	.28568
DECIMALS: DECIMAL DIVIDED BY DECIMAL (O 15)	.32822	.48521	.28092	.03421
FRACTIONS: MULTIPLY FRACTIONS (O 7)	.12979	.45878	.10258	.05192

TABLE C-11--Continued

Objectives	Factors**			
	I	II	III	IV
FRACTIONS: SUBTRACT MIXED NUMBERS UNLIKE DENOMINATORS (O 6)	.21734	.15522	.69860	.08404
FRACTIONS: SUBTRACT FRACTIONS UNLIKE DENOMINATORS (N 13)	.38025	.07941	.65442	.21309
FRACTIONS: SUBTRACT MIXED NUMBERS UNLIKE DENOMINATORS (N 14)	.41330	.16997	.65262	.14922
FRACTIONS: SUBTRACT FRACTIONS UNLIKE DENOMINATORS (O 5)	.17731	.40400	.59281	.36058
FRACTIONS: WHOLE NUMBER X MIXED NUMBER (O 9)	.20497	.22072	.45805	.13651
FRACTIONS: WHOLE NUMBER X MIXED NUMBER (N 16)	.30102	.15191	.42482	.08519
ALGEBRA: EVALUATE COMMON ALG EXP (O 37)	.37242	.23043	.38943	.31516
FRACTIONS: FIND THE LARGER OF TWO FRACTIONS (O 3)	.20147	.40914	.29290	.50749
GEOMETRY: PARTS OF A CIRCLE (O 33)	.21164	.44408	.19160	.47153
DECIMALS: DECIMAL X DECIMAL (O 14)	.19314	.44788	.27938	.46155

*Old test scores recoded as follows: 0=0 1=1.5 2=1.5 3=3 4=3.

**Objectives are arranged according to factor loadings. The highest factor loading for each objective is contained in a rectangle.

TABLE C-12

ROTATED FACTOR MATRIX
40 OBJECTIVES NOT COMMON TO THE
OLD (1979) AND NEW (1980) GRADE 10 MEAP MATHEMATICS TESTS
OLD TEST SCORES RECODED* NEW TEST SCORES UNCHANGED

Objectives	Factors**					
	I	II	III	IV	V	VI
WHOLE NUMBER DIVISION: WORD PROBLEMS (N 2)	.70011	.13383	.12874	.13737	.34250	.02729
WHOLE NUMBER DIVISION: COMPUTATION (N 1)	.69848	.15524	.05554	.12894	.12653	.02752
DECIMALS: WORD PROBLEMS, MULTIPLICATION (N 6)	.59897	.11976	.25189	.14322	.14040	.18419
DECIMALS: DECIMAL DIVIDED BY WHOLE NUMBER (N 7)	.58175	.18168	.32838	.13369	.08424	.27485
NON-METRIC MEAS: TIME CONVERSION (N 22)	.51447	.16428	.19837	.06103	.48143	.05717
NON-METRIC MEAS: MONEY WORD PROBLEMS (N 23)	.51279	.15801	.24304	.16644	.07225	.10044
FRACTIONS: CONVERT MIXED NOS. TO COMMON FRACTIONS (N 10)	.49411	.22162	.28419	.17030	.12677	.24395
PROB & STAT: PROBABILITY OF A SIMPLE EVENT (N 25)	.47363	.13914	.39897	.09762	.20319	.06722
DECIMALS: CONVERT FRACTIONS TO DECIMALS (N 3)	.43873	.18475	.35391	.05755	.39937	.17694
METRIC MEAS: VOLUME COMPUTATION (N 20)	.41519	.19707	.32289	.05735	.27486	.16009
NON-GEOM MEAS: GIVEN COST, WHAT COULD BE PURCHASED (O 31)	.18119	.69487	.03236	.43494	.11091	.04779
PROB & STAT: ANSWER QUESTIONS USING BAR GRAPH (O 38)	.17826	.68510	.19302	.22116	.23094	.01151
WHOLE NUMBER DIVISION: COMPUTATION (O 1)	.23102	.67022	.05552	.37026	.13845	.21840
GEOM MEAS: WORD PROBLEM--STANDARD UNITS OF MEASURE (O 25)	.20939	.59285	.37586	.17442	.22939	.10648
DECIMALS: CONVERT COMMON FRACTION TO DECIMAL (O 11)	.21500	.56790	.38077	.07468	.27155	.10164

TABLE C-12--Continued

Objectives	Factors**					
	I	II	III	IV	V	VI
RATIO PROP %: DETERMINE PERCENTAGE OF GIVEN NUMBER (O 21)	.13463	.55856	.25506	.22635	.10405	.10953
GEOM MEAS: WORD PROBLEM--RECTANGLES, TRIANGLES, CIRCLES (O 29)	.13690	.51524	.40985	.13953	.19060	.14689
FRACTIONS: FIND A SET OF EQUIVALENT FRACTIONS (O 2)	.18047	.42293	.29459	.38121	.16223	.16522
METRIC MEAS: AREA WORD PROBLEMS (N 19)	.28926	.22699	.57768	.08127	.09799	.02041
GEOM MEAS: MEASURE TRIANGLE & FIND AREA (O 28)	.09295	.25501	.49185	.00559	.13237	.12452
FRACTIONS: ADDITION WORD PROBLEMS (N 12)	.31771	.05147	.48985	.12012	.16822	.30703
NON-METRIC MEAS: ANGLE MEASUREMENT (N 21)	.27984	.10764	.47709	.12520	.07928	.02462
FRACTIONS: ADD FRACTIONS WITH UNLIKE DENOMINATORS (N 11)	.36718	.08798	.47286	.07971	.16559	.31471
GEOM MEAS: FIND PERIMETER OF POLYGONS & CIRCLES (O 24)	.14194	.31423	.38891	.28139	.36798	.17473
RATIO PROP %: WRITE EQUIVALENT RATIO--SUPPLY WHOLE NUMBER (O 19)	.15009	.12326	.37482	.02836	.35157	.05951
NON-GEOM MEAS: MULTIPLY/DIVIDE MONEY BY POS INTEGER (O 32)	.16300	.24310	.06195	.78110	.06136	.12874
RATIO PROP %: WRITE RATIO DESCRIBING INDICATED COMPARISON (O 18)	.08426	.23809	.08301	.74207	.03348	.04666
GEOM MEAS: LOCATE ITEMS IN A TABLE OF DATA (O 27)	.13770	.55161	.02250	.61378	.08429	.02407
PROB & STAT: PREDICT NUMBER OF TIMES EVENT WILL OCCUR (O 39)	.16567	.26993	.25597	.51501	.31269	.13663

TABLE C-12--Continued

Objectives	Factors**					
	I	II	III	IV	V	VI
GEOMETRY: IDENTIFY CONGRUENT & NON-CONGRUENT FIGURES (O 34)	.11242	.09744	.03151	.50033	.40464	-.02906
ALGEBRA: WRITE R**N AS N FACTORS OF R (O 36)	.19603	.19503	.08380	.33442	.28511	.29322
NON-GEOM MEAS: FIND DIFFERENCE IN TIME INTERVALS (O 30)	.20309	.11863	.09739	.38125	.54669	.11562
DECIMALS: ROUND TO NEAREST 1, .1, .01 (O 10)	.19154	.22763	.09448	.21104	.48178	.08239
INTEGERS: LOCATE INTEGERS ON A NUMBER LINE (O 16)	.15807	.17378	.21318	.06594	.46637	.31116
GEOM MEAS: MEASURE OBJECT TO NEAREST UNIT (O 23)	.15406	.14315	.35722	.04449	.42531	.06545
INTEGERS: ADD INTEGERS (O 17)	.19088	.23956	.31535	.05998	.39838	.24984
ALGEBRA: SOLVE LINEAR EQUATION (O 35)	.21567	.10232	.12308	.12789	.36971	.34945
FRACTIONS: ADD MIXED NUMBERS (O 4)	.33251	.12590	.35464	.05019	.29396	.41431
FRACTIONS: WHOLE NUMBER X FRACTION (O 8)	.23944	.20278	.20857	.16735	.26052	.35440
DECIMALS: DECIMAL X WHOLE NO. POWER OF 10 (O 13)	.21565	.22195	.25950	.26643	.19433	.32945

*Old test scores were recoded as follows: 0=0 1=1.5 2=1.5 3=3 4=3.

**Objectives are arranged according to factor loadings. The highest factor loading for each objective is contained in a rectangle.

TABLE C-13

PEARSON PRODUCT-MOMENT CORRELATION COEFFICIENTS AMONG FACTOR SCORES FROM THE 14 PAIRS OF COMMON OBJECTIVES AND 40 OBJECTIVES NOT COMMON TO THE OLD* (1979) AND NEW (1980) GRADE 10 MEAP MATHEMATICS TESTS (N = 557)

Objectives	14 Pairs Of Common Objectives				40 Objectives Not Common					
	Factor I	Factor II	Factor III	Factor IV	Factor I	Factor II	Factor III	Factor IV	Factor V	Factor VI
14 Common										
Factor I	1.0000	0.0584	0.1510	0.0729	0.7370	0.0471	0.3405	0.0269	0.2189	0.1120
	P=*****	P=0.084	P=0.000	P=0.043	P=0.000	P=0.134	P=0.000	P=0.263	P=0.000	P=0.004
Factor II	0.0584	1.0000	0.0430	0.1517	0.0336	0.4364	0.0881	0.7616	0.1853	0.0746
	P=0.084	P=*****	P=0.155	P=0.000	P=0.215	P=0.000	P=0.019	P=0.000	P=0.000	P=0.039
Factor III	0.1510	0.0430	1.0000	0.1442	0.3051	0.1637	0.4210	-0.0115	0.3134	0.5419
	P=0.000	P=0.155	P=*****	P=0.000	P=0.000	P=0.000	P=0.000	P=0.394	P=0.000	P=0.000
Factor IV	0.0729	0.1517	0.1442	1.0000	0.0912	0.6206	0.2515	0.0360	0.1540	0.0720
	P=0.043	P=0.000	P=0.000	P=*****	P=0.016	P=0.000	P=0.000	P=0.198	P=0.000	P=0.045
40 Not Common										
Factor I	0.7370	0.0336	0.3051	0.0912	1.0000	0.0151	0.1097	0.0273	0.0974	0.0770
	P=0.000	P=0.215	P=0.000	P=0.016	P=*****	P=0.361	P=0.005	P=0.260	P=0.011	P=0.035
Factor II	0.0471	0.4364	0.1637	0.6206	0.0151	1.0000	0.0854	0.1264	0.0383	0.0043
	P=0.134	P=0.000	P=0.000	P=0.000	P=0.361	P=*****	P=0.022	P=0.001	P=0.183	P=0.459
Factor III	0.3405	0.0881	0.4210	0.2515	0.1097	0.0854	1.0000	-0.0518	0.1035	0.1756
	P=0.000	P=0.019	P=0.000	P=0.000	P=0.005	P=0.022	P=*****	P=0.111	P=0.007	P=0.000
Factor IV	0.0269	0.7616	-0.0115	0.0360	0.0273	0.1264	-0.0518	1.0000	0.0351	0.0518
	P=0.263	P=0.000	P=0.394	P=0.198	P=0.260	P=0.001	P=0.111	P=*****	P=0.204	P=0.111
Factor V	0.2189	0.1853	0.3134	0.1540	0.0974	0.0383	0.1035	0.0351	1.0000	0.1102
	P=0.000	P=0.000	P=0.000	P=0.000	P=0.011	P=0.183	P=0.007	P=0.204	P=*****	P=0.005
Factor VI	0.1120	0.0746	0.5419	0.0720	0.0770	0.0043	0.1756	0.0518	0.1102	1.0000
	P=0.004	P=0.039	P=0.000	P=0.045	P=0.035	P=0.459	P=0.000	P=0.111	P=0.005	P=*****

*Old test scores were recoded as follows: 0=0 1=1.5 2=1.5 3=3 4=3.

TABLE C-14

ROTATED FACTOR MATRIX
14 PAIRS OF COMMON OBJECTIVES
OLD (1979) AND NEW (1980) GRADE 10 MEAP MATHEMATICS TESTS
OLD AND NEW TEST SCORES RECODED*

Objectives	Factors**				
	I	II	III	IV	V
PROB & STAT: FIND THE MEAN OF A SET OF NUMBERS (N 26)	.67607	.14110	.18147	.04237	.09654
DECIMALS: DECIMAL X DECIMAL (N 5)	.61491	.18417	.22252	.05840	.04063
RATIO PROP %: WORD PROBLEM--FIND PERCENTAGE OF A NUMBER (N 18)	.58854	.17340	.18766	.27366	.12340
DECIMALS: ORDER SET OF DECIMALS (N 4)	.56803	.21093	.04808	.12224	.10220
FRACTIONS: MULTIPLY FRACTIONS (N 15)	.55614	.16370	.05130	.11621	.02934
EQUATIONS EXP GRAPHS: EVALUATE COMMON ALG EXP (N 27)	.55317	.18482	.29256	.36537	.13333
DECIMALS: DECIMAL DIVIDED BY DECIMAL (N 8)	.49587	.18587	.19205	-.04861	.15196
EQUATIONS EXP GRAPHS: READ A COORDINATE SYSTEM (N 28)	.48705	.15273	.12681	.12693	.14881
FRACTIONS: FIND THE LARGER OF TWO FRACTIONS (N 9)	.47025	.14879	.26235	.23870	.20404
GEOMETRY: PARTS OF A CIRCLE (N 24)	.41094	.05968	.14874	.24332	.14024
RATIO PROP %: CONVERT FRACTIONS DECIMALS PERCENTS (N 17)	.41049	.19093	.16930	.08239	.23146
PROB & STAT: FIND THE MEAN OF A SET OF NUMBERS (O 40)	.37303	.27594	.24439	.06714	.07223
GEOM MEAS: READ A COORDINATE SYSTEM (O 26)	.12277	.73460	-.04239	.09347	.13183
DECIMALS: ORDER A SET OF DECIMALS (O 12)	.20700	.65924	.10451	.14595	.05381
RATIO PROP %: CONVERT FRACTIONS DECIMALS PERCENTS (O 20)	.17214	.64309	.19511	.11862	.17014
RATIO PROP %: WORD PROBLEM--FIND PERCENTAGE OF A NUMBER (O 22)	.21513	.60750	.11460	.27478	.07210

TABLE C-14--Continued

Objectives	Factors**				
	I	II	III	IV	V
DECIMALS: DECIMAL DIVIDED BY DECIMAL (O 15)	.33186	$\boxed{.49286}$	.21349	.03735	.15778
FRACTIONS: MULTIPLY FRACTIONS (O 7)	.12838	$\boxed{.47172}$	.11781	.04865	-.01926
FRACTIONS: SUBTRACT MIXED NUMBERS UNLIKE DENOMINATORS (O 6)	.23437	.17716	$\boxed{.69228}$	.07420	.20139
FRACTIONS: SUBTRACT MIXED NUMBERS UNLIKE DENOMINATORS (N 14)	.45365	.18418	$\boxed{.59509}$	.13327	.18267
FRACTIONS: SUBTRACT FRACTIONS UNLIKE DENOMINATORS (N 13)	.40167	.06290	$\boxed{.58718}$	.24924	.18149
FRACTIONS: SUBTRACT FRACTIONS UNLIKE DENOMINATORS (O 5)	.21517	.40712	$\boxed{.54093}$	.38651	.16419
ALGEBRA: EVALUATE COMMON ALG EXP (O 37)	.36435	.25441	$\boxed{.37314}$	.31157	.09307
FRACTIONS: FIND THE LARGER OF TWO FRACTIONS (O 3)	.20901	.39573	.19040	$\boxed{.53989}$	.21563
DECIMALS: DECIMAL X DECIMAL (O 14)	.21692	.44311	.22799	$\boxed{.47797}$	.09794
GEOMETRY: PARTS OF A CIRCLE (O 33)	.21775	.44676	.13752	$\boxed{.47381}$	.10008
FRACTIONS: WHOLE NUMBER X MIXED NUMBER (N 16)	.28645	.10497	.16694	.09845	$\boxed{.64954}$
FRACTIONS: WHOLE NUMBER X MIXED NUMBER (O 9)	.18584	.19588	.27385	.16725	$\boxed{.53319}$

*Old test scores were recoded as follows: 0=0 1=1.5 2=1.5 3=3 4=3.

New test scores were recoded as follows: 0=0 1=1.5 2=1.5 3=3.

**Objectives are arranged according to factor loadings. The highest factor loading for each objective is contained in a rectangle.

TABLE C-15

ROTATED FACTOR MATRIX
40 OBJECTIVES NOT COMMON TO THE
OLD (1979) AND NEW (1980) GRADE 10 MEAP MATHEMATICS TESTS
OLD AND NEW TEST SCORES RECODED*

Objectives	Factors**					
	I	II	III	IV	V	VI
WHOLE NUMBER DIVISION: WORD PROBLEMS (N 2)	.67318	.13634	.12351	.12248	.31077	.12761
WHOLE NUMBER DIVISION: COMPUTATION (N 1)	.65947	.11816	.11093	.04339	.10746	.06712
DECIMALS: WORD PROBLEMS, MULTIPLICATION (N 6)	.59322	.13136	.15431	.26588	.10231	.17300
DECIMALS: DECIMAL DIVIDED BY WHOLE NUMBER (N 7)	.58542	.19214	.13302	.31957	.00734	.25520
NON-METRIC MEAS: MONEY WORD PROBLEMS (N 23)	.52223	.15863	.16961	.21263	.07141	.07997
FRACTIONS: CONVERT MIXED NOS. TO COMMON FRACTIONS (N 10)	.51128	.21383	.17109	.27292	.07924	.23638
PROB & STAT: PROBABILITY OF A SIMPLE EVENT (N 25)	.49618	.17013	.09409	.34764	.16757	.08901
NON-METRIC MEAS: TIME CONVERSION (N 22)	.48808	.14350	.07336	.21518	.39731	.13656
DECIMALS: CONVERT FRACTIONS TO DECIMALS (N 3)	.44163	.20389	.06730	.32323	.29480	.23776
METRIC MEAS: VOLUME COMPUTATION (N 20)	.43281	.22277	.05034	.28640	.22957	.21043
PROB & STAT: ANSWER QUESTIONS USING BAR GRAPH (O 38)	.19100	.67955	.24652	.16543	.22315	.05160
NON-GEOM MEAS: GIVEN COST, WHAT COULD BE PURCHASED (O 31)	.19682	.67280	.46273	.00630	.09484	.07466
WHOLE NUMBER DIVISION: COMPUTATION (O 1)	.24732	.64572	.39748	.03505	.08368	.24964
GEOM MEAS: WORD PROBLEM--STANDARD UNITS OF MEASURE (O 25)	.21605	.59873	.19061	.35915	.20295	.14495
DECIMALS: CONVERT COMMON FRACTION TO DECIMAL (O 11)	.23613	.58600	.08106	.34463	.23066	.16811

TABLE C-15--Continued

Objectives	Factors**					
	I	II	III	IV	V	VI
RATIO PROP %: DETERMINE PERCENTAGE OF GIVEN NUMBER (O 21)	.13283	.55879	.24465	.24974	.07784	.12256
GEOM MEAS: WORD PROBLEM--RECTANGLES, TRIANGLES, CIRCLES (O 29)	.16722	.52998	.14240	.37508	.14773	.19248
FRACTIONS: FIND A SET OF EQUIVALENT FRACTIONS (O 2)	.19349	.41421	.39497	.29524	.13899	.16354
NON-GEOM MEAS: MULTIPLY/DIVIDE MONEY BY POS INTEGER (O 32)	.15259	.21034	.79125	.07417	.05209	.13298
RATIO PROP %: WRITE RATIO DESCRIBING INDICATED COMPARISON (O 18)	.08011	.21391	.75081	.09208	.02560	.05572
GEOM MEAS: LOCATE ITEMS IN A TABLE OF DATA (O 27)	.14285	.52548	.63420	.00907	.08990	.03735
PROB & STAT: PREDICT NUMBER OF TIMES EVENT WILL OCCUR (O 39)	.16261	.26549	.51465	.24617	.28081	.20848
GEOMETRY: IDENTIFY CONGRUENT & NON-CONGRUENT FIGURES (O 34)	.12100	.08976	.48675	.01359	.42040	.06197
FRACTIONS: ADDITION WORD PROBLEMS (N 12)	.32880	.05851	.12446	.53295	.12303	.25851
METRIC MEAS: AREA WORD PROBLEMS (N 19)	.32591	.23700	.06819	.51643	.08952	.03364
FRACTIONS: ADD FRACTIONS WITH UNLIKE DENOMINATORS (N 11)	.38339	.07957	.08568	.50985	.10495	.27389
NON-METRIC MEAS: ANGLE MEASUREMENT (N 21)	.30277	.12989	.13617	.46387	.07048	.00449
GEOM MEAS: MEASURE TRIANGLE & FIND AREA (O 28)	.11907	.28047	-.00198	.45454	.11104	.14438
GEOM MEAS: FIND PERIMETER OF POLYGONS & CIRCLES (O 24)	.15625	.32353	.28037	.37970	.31923	.24228

TABLE C-15--Continued

Objectives	Factors**					
	I	II	III	IV	V	VI
RATIO PROP Z: WRITE EQUIVALENT RATIO--SUPPLY WHOLE NUMBER (O 19)	.16578	.14665	.01613	.33981	.33878	.13281
NON-GEOM MEAS: FIND DIFFERENCE IN TIME INTERVALS (O 30)	.20440	.10663	.37815	.10647	.52007	.21595
DECIMALS: ROUND TO NEAREST 1, .1, .01 (O 10)	.20259	.23007	.20289	.06169	.46351	.19743
GEOM MEAS: MEASURE OBJECT TO NEAREST UNIT (O 23)	.15962	.16134	.03412	.34322	.41498	.14398
INTEGERS: ADD INTEGERS (O 17)	.19411	.25047	.05692	.31132	.33628	.32847
ALGEBRA: SOLVE LINEAR EQUATION (O 35)	.20535	.09756	.12807	.13500	.26503	.44760
FRACTIONS: WHOLE NUMBER X FRACTION (O 8)	.24697	.20108	.16806	.19923	.16070	.42928
FRACTIONS: ADD MIXED NUMBERS (O 4)	.33869	.11919	.06227	.39464	.20868	.40789
ALGEBRA: WRITE R**N AS N FACTORS OF R (O 36)	.19009	.18211	.33716	.07825	.20055	.38777
INTEGERS: LOCATE INTEGERS ON A NUMBER LINE (O 16)	.17074	.17161	.06838	.23525	.38141	.38196
DECIMALS: DECIMAL X WHOLE NO. POWER OF 10 (O 13)	.22780	.21610	.26604	.26393	.12798	.35362

*Old test scores were recoded as follows: 0=0 1=1.5 2=1.5 3=3 4=3.

New test scores were recoded as follows: 0=0 1=1.5 2=1.5 3=3.

**Objectives are arranged according to factor loadings. The highest factor loading for each objective is contained in a rectangle.

TABLE C-16

PEARSON PRODUCT-MOMENT CORRELATION COEFFICIENTS AMONG FACTOR SCORES FROM THE 14 PAIRS OF COMMON OBJECTIVES AND 40 OBJECTIVES NOT COMMON TO THE OLD* (1979) AND NEW* (1980) GRADE 10 MEAP MATHEMATICS TESTS (N = 557)

Objectives	14 Pairs Of Common Objectives					40 Objectives Not Common					
	Factor I	Factor II	Factor III	Factor IV	Factor V	Factor I	Factor II	Factor III	Factor IV	Factor V	Factor VI
14 Common											
Factor I	1.0000 P=*****	0.0590 P=0.082	0.1294 P=0.001	0.0733 P=0.042	0.0943 P=0.013	0.7487 P=0.000	0.0779 P=0.033	0.0227 P=0.296	0.3292 P=0.000	0.1794 P=0.000	0.1556 P=0.000
Factor II	0.0590 P=0.082	1.0000 P=*****	0.0197 P=0.321	0.1618 P=0.000	0.0554 P=0.096	0.0391 P=0.178	0.4081 P=0.000	0.7666 P=0.000	0.0687 P=0.053	0.2028 P=0.000	0.1565 P=0.000
Factor III	0.1294 P=0.001	0.0197 P=0.321	1.0000 P=*****	0.1277 P=0.001	0.1374 P=0.001	0.2806 P=0.000	0.1117 P=0.004	-0.0282 P=0.253	0.3519 P=0.000	0.1930 P=0.000	0.5427 P=0.000
Factor IV	0.0733 P=0.042	0.1618 P=0.000	0.1277 P=0.001	1.0000 P=*****	0.0632 P=0.068	0.1138 P=0.004	0.6360 P=0.000	0.0581 P=0.085	0.2234 P=0.000	0.1395 P=0.000	0.1151 P=0.003
Factor V	0.0943 P=0.013	0.0554 P=0.096	0.1374 P=0.001	0.0632 P=0.068	1.0000 P=*****	0.1499 P=0.000	0.0988 P=0.010	0.0312 P=0.231	0.3939 P=0.000	0.1026 P=0.008	0.1442 P=0.000
40 Not Common											
Factor I	0.7487 P=0.000	0.0391 P=0.178	0.2806 P=0.000	0.1138 P=0.004	0.1499 P=0.000	1.0000 P=*****	0.0267 P=0.265	0.0260 P=0.270	0.1365 P=0.001	0.0735 P=0.042	0.1001 P=0.009
Factor II	0.0779 P=0.033	0.4081 P=0.000	0.1117 P=0.004	0.6360 P=0.000	0.0988 P=0.010	0.0267 P=0.265	1.0000 P=*****	0.1185 P=0.003	0.0757 P=0.037	0.0397 P=0.175	0.0229 P=0.295
Factor III	0.0227 P=0.296	0.7666 P=0.000	-0.0282 P=0.253	0.0581 P=0.085	0.0312 P=0.231	0.0260 P=0.270	0.1185 P=0.003	1.0000 P=*****	-0.0492 P=0.123	0.0338 P=0.213	0.0552 P=0.097
Factor IV	0.3292 P=0.000	0.0687 P=0.053	0.3519 P=0.000	0.2234 P=0.000	0.3939 P=0.000	0.1365 P=0.001	0.0757 P=0.037	-0.0492 P=0.123	1.0000 P=*****	0.0765 P=0.036	0.1748 P=0.000
Factor V	0.1794 P=0.000	0.2028 P=0.000	0.1930 P=0.000	0.1395 P=0.000	0.1026 P=0.008	0.0735 P=0.042	0.0397 P=0.175	0.0338 P=0.213	0.0765 P=0.036	1.0000 P=*****	0.1873 P=0.000
Factor VI	0.1556 P=0.000	0.1565 P=0.000	0.5427 P=0.000	0.1151 P=0.003	0.1442 P=0.000	0.1001 P=0.009	0.0229 P=0.295	0.0552 P=0.097	0.1748 P=0.000	0.1873 P=0.000	1.0000 P=*****

*Old test scores were recoded as follows: 0=0 1=1.5 2=1.5 3=3 4=3.
New test scores were recoded as follows: 0=0 1=1.5 2=1.5 3=3.

APPENDIX D

Grade Ten

Michigan Educational Assessment Program

Mathematics Test

Instruments

Michigan Educational Assessment Program

STUDENT ASSESSMENT BOOKLET

MATHEMATICS

GRADE 10

1979-1980

Michigan Department of Education

MICHIGAN STATE BOARD OF EDUCTAION

STATEMENT OF ASSURANCE OF COMPLIANCE WITH FEDERAL LAW

The Michigan State Board of Education hereby agrees that it will comply with Federal laws prohibiting discrimination and with all requirements imposed by or pursuant to regulations of the U.S. Department of Health, Education and Welfare. Therefore, it shall be the policy of the Michigan State Board of Education that no person on the basis of race, color, religion, national origin or ancestry, age, sex, or marital status shall be discriminated against, excluded from participation in, be denied the benefits of, or be otherwise subjected to discrimination under any federally funded program or activity for which the Michigan State Board of Education is responsible or for which it receives federal financial assistance from the Department of Health, Education and Welfare. This policy of nondiscrimination shall also apply to otherwise qualified handicapped individuals.

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ABSTRACT

A COMPARATIVE ANALYSIS OF THE STRUCTURE OF TWO VERSIONS OF THE GRADE TEN MICHIGAN EDUCATIONAL ASSESSMENT PROGRAM MATHEMATICS TEST

by

JoAnne Ellen Moore

April, 1983

Adviser: Donald R. Marcotte

Major: Educational Evaluation and Research

Degree: Doctor of Philosophy

Each year the Michigan Educational Assessment Program (MEAP) tests all Michigan students' knowledge of basic reading and mathematics skills at grades four, seven, and ten using an objective-referenced test. In 1980, these tests were revised in terms of the numbers of objectives and skills tested, and the numbers of items per objective. This study examined the old and new forms of the Grade 10 MEAP mathematics test using a series of factor analyses which attempted to uncover the underlying structures of the two forms of the test. The purpose of these analyses was to ascertain if the factor structure of the fourteen objectives which were common to the two instruments was maintained when the number of items per objective was reduced; secondly, to determine if the uncommon objectives measured similar traits; and, finally, to compare the

performance of students who took both forms of the test to determine to what extent longitudinal comparisons across forms of the test were appropriate.

Principal components analysis with iterations followed by varimax rotation was used and factor scores were produced for each of the 557 subjects in this study. These scores were then correlated in order to determine the relationships among the factors produced by the two forms of the test. This procedure was appropriate since each of the subjects had taken both forms of the Grade 10 MEAP mathematics test.

The old and new forms of the Grade 10 MEAP mathematics test were found to be different in several ways. The old form of the test yielded five factors while the new form yielded three. When the fourteen objectives which were common to the two forms were factor analyzed together, omitting the additional objectives from both tests, the resulting factors reflected the tendency of objectives to cluster on factors based upon the test form rather than the content of the objectives. This result also occurred when the remaining objectives were factor analyzed and persisted through four attempts to account for it by recoding the scores. Decisions based upon the results of the two forms were also found to be different using the MEAP criteria.

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