Technical Manual For The

Diagnostic Test for High School Math (DT-HSM)

By
Joel P. Wiesen, Ph.D., Director

APR Testing Services
27 Judith Road
Newton, Massachusetts 02459
(617) 244-7405
Support@APRTestingServices.com

October 1, 2003
Version 1.3

27 Judith Road
Newton, Massachusetts 02459
(617) 244-7405
Support@APRTestingServices.com

Table of Contents

Chapter 1. Introduction

The mathematics achievement of individual students has always been very important, but recently it has become the subject of renewed focus. Many states have recently introduced statewide testing requirements for graduation from high school. Not only are students being judged and held accountable, but also schools and school administrators are being judged by the test performance of their students. There has long been a need for an efficient, wide ranging diagnostic math test to assess students in a way which would help pinpoint their weaknesses. This need arises from the simple fact that much of the math curriculum builds on basic competencies, such as adding numbers or using fractions, and often success in later courses is impossible without mastery of material covered in earlier courses. The Diagnostic Test for High School Mathematics (DT-HSM) is designed to provide diagnostic information on the competencies of individual students in various areas of basic, high school math. This information may be used to direct instruction, which should help students to do better on mandated statewide assessments.

Massachusetts Comprehensive Assessment System (MCAS)

Massachusetts is one of many states that have instituted new statewide testing programs in the public schools. A fundamental goal of education reform in Massachusetts is to raise expectations and promote high standards for all the students of the Commonwealth. A central aspect of this reform is the establishment of the Massachusetts Comprehensive Assessment System (MCAS), a statewide testing program conducted the past several years at the 4^{th}, 8^{th}, and 10^{th} grade levels and now being expanded to additional grades. Successful performance will be required for graduation from high school beginning in the year 2003. The Massachusetts Department of Education has released the test questions for several of its tests. Much of the development of the Diagnostic Test for High School Mathematics (DT-HSM) was guided by analysis of these sets of released test questions.

One important feature of statewide tests such as the MCAS is that the questions generally require students to use several competencies. In this way the test reflects the way mathematics is used in the real world. However, this type of test question is not ideal for diagnosing specific limitations in a student's mathematical skills. If a student answers a particular question incorrectly, it could be because of lack of knowledge in any of several content areas. These statewide tests only provide an indication of overall level of performance.

Need for a Diagnostic Math Test

There is clearly a need for a diagnostic math test to assist students, teachers, and curriculum developers in monitoring progress and identifying weaknesses. Also, parents often ask, “What should my child do to improve in math?” Frequently schools lack the diagnostic information which would

allow a specific response. The range of possible knowledge gaps is great. One student may have failed to learn how to add and subtract signed numbers. Another may have failed to master addition of common fractions. Another student may not have learned even the most basic aspects of percentages. Statewide tests such as the MCAS provide an overall measure of competence, not diagnostic information. So, there is clearly a need for a diagnostic math test to assist students in remediation. The DT-HSM was developed to provide diagnostic information on individual students as well as on groups of students to help solve this problem.

Need for an Overall Math Assessment

School administrators make placement decisions at the end of the 9th or 10th grade concerning placement of individual students in various pre-calculus or calculus courses in the following year. A test which provides an overall evaluation of the level of mastery of pre-calculus math would be useful in this placement process.

DT-HSM Diagnostic Areas: Content Analysis of the MCAS

A content analysis was conducted of the May 1998, Spring 1999, Spring 2000, and Spring 2001 MCAS 10th grade mathematics released test questions (Massachusetts Department of Education, 1998, 1999, 2000, and 2001). Specifically, for each test question the mathematical competencies required to correctly answer the question were identified. Twenty competencies were found to be necessary to answer the MCAS questions. The 20 competencies are listed in Table 1. The majority of the questions in the MCAS require more than one competency. This part of the development of the DT-HSM is covered in more detail in Chapter 3.

Table 1. Competencies Needed to Answer the MCAS 10th Grade Math Questions			
1	Whole Numbers	11	Graphs
2	Common Fractions	12	Tables
3	Decimal Fractions	13	Estimation
4	Percentages	14	Probability
5	Signed Numbers	15	Statistics
6	Powers and Roots	16	Order of Operations
7	Substitution	17	Ratios
8	Setting up Equations	18	Math Vocabulary
9	Solving Algebraic Equations	19	Word Problems
10	Geometry	20	Miscellaneous

DT-HSM Score Reports

There are three DT-HSM score reports:

- The Student Report is a one page score report intended for use by the student and his or her parents/guardians. It reports number correct in each of the 20 competency areas and total correct and total percent correct.
- The Class Report is intended for use by the teacher(s). It presents a summary for each class in terms of number and percent correct overall and by area, a listing of diagnostic and total scores for each student in each class, and the distribution of total scores for each class.
- The School-Wide Report is intended for use by the administration. It highlights areas of greatest weakness in each class, reports on the number of questions left blank and the number with multiple answers, and shows the distribution of total scores within the school district.

Individual student scores are also available to the school in a computer compatible format (such as MSExcel).

Value of Using the DT-HSM

The DT-HSM will allow a teacher, parent, or student to target remedial efforts, thereby maximizing efficiency of the remedial efforts and yielding improvement in the shortest time.

Since the DT-HSM is group administered, it is much less expensive than an individually administered assessment. The DT-HSM can be given at the start of a school year when the teacher does not know the students, and thereby quickly provide the teacher with detailed information about the strengths and weaknesses of individual students. Despite its usefulness, the DT-HSM is not meant to be a complete substitute for an individualized student evaluation by a competent guidance counselor or teacher.

The DT-HSM may be used by school administrators to track student performance over years, and to help evaluate the math curriculum.

This manual provides information about the DT-HSM materials, administration, scoring, development, norms, and use.

Chapter 2. Use, Administration, and Scoring of the DT-HSM

The DT-HSM materials include this manual, a disposable question booklet, and a machine-scorable answer sheet. (A version that is scored over the web is also available. Information on it is available on the web at: http://APRTestingServices.com. This chapter focuses on the use of the paper answer sheet.) Completed answer sheets are returned to the publisher for computer scoring. The grade reports provided by the publisher include: (1) student reports - a listing of scores, one page per student, meant for use by individual students, (2) class reports - a summary listing of the student scores by class, and (3) a school-wide report - a set of summary statistics for the scores for all students. The DT-HSM is easy to administer and is suitable for administration to groups. (The computerized version is better for testing individuals.) This chapter provides instruction for administering the DT-HSM and for understanding and using the grade reports.

Qualifications to use the DT-HSM

The DT-HSM was designed for use by high school teachers. No specific professional qualifications in testing are required to use and administer the DT-HSM. However, teachers and administrators should follow the test administration instructions. Interpretation of the DT-HSM reports may reasonably be made by the personnel for whom they are intended. Teachers and administrators using the DT-HSM score reports should first carefully review the material in this manual.

Maintaining Test Security

The DT-HSM is a secure test. The questions should not be shared with students or parents. The test areas may be shared (for example as presented in Table 1 in Chapter 1 or in the tables in Chapter 3.) Care should be taken that the test is stored and discarded in a secure manner. The tests should be kept under lock and key at all times when not in use.

Intended Uses

There are three intended uses for the DT-HSM: (1) to identify possible areas of weakness of individual students currently taking pre-calculus math or beginning a calculus course, (2) to assess overall readiness of a student or group of students to undertake a first calculus course, and (3) to evaluate progress of grades/classes over time, such as from year to year.

Test Administration

The DT-HSM may be administered in 90 minutes, as a timed test. The amount of introduction that a teacher will give a class concerning this test may depend on the amount and type of contact the students have had with standardized tests. The teacher should encourage students to do their best, but not create undue anxiety about the test. All students who may be compared on their DT-HSM scores

should take the test under test conditions which are as similar as possible. The school should check the ID numbers on the student answer sheets to be sure they have been completed correctly. If this is not done, student results may be grouped with the wrong class, or there may be some other confusion in the score reports.

Motivation of the Students

A student's performance on a test such as the DT-HSM is a reflection of the student's ability and other factors such as his or her level of attention, motivation, or effort in taking the test. A student's test results will be more accurate if the student pays attention and does careful work while taking the examination. The teacher should prepare the students for this test with this in mind.

Introducing the DT-HSM to Students

Efforts should be made to minimize test anxiety. Any test may be threatening. When possible, reassure the students that the test results will not be used against them, that they will not be reassigned to a lower class as a result of their test score, and that they will have an opportunity to address any weaknesses with extra curriculum material. (Of course, if any of these statements are not true, that reassurance should not be given.) This introduction might best be done a day or two before the actual test to allow for maximum testing time on the day of the test administration.

Answering Students' Questions

Prior to the day of test administration, students should be given an opportunity to ask questions about the DT-HSM. Students may be told what the test will cover and may even be given a copy of the list of competencies. During the test itself, if the teacher or proctor helps a student answer any questions the resulting grade will reflect the competency of both the student and the teacher/proctor. If a student asks, "Am I on the right path?" the proctor should explain that the testing time is not a lesson, and that the student needs to answer the questions without help. It is rare to get questions from students while the test is in progress.

Use of Calculators

Schools may wish to mirror the test administration conditions mandated for their official statewide tests. The DT-HSM norms in this manual are for groups who took the test without the aid of calculators. Scores for students who take the test with calculators are not directly comparable to scores for students who do not use calculators.

Answer Sheet Competency

If students are not familiar with use of computer scored answer sheets, they may need instruction in the use of the answer sheets. This might best take place a day or so before the test administration, and might include the students filling out the ID sections of the answer sheet. Some of the things students need to know concerning answer sheets are listed below, together with related problems. In short, students may not get credit for what they know if they fill out the answer sheets incorrectly.

1. Fill in bubble spaces completely.
   The correct way to fill in the bubbles is by shading the entire circle dark enough so that the letters cannot be seen through the shading. The pencil marks must be within the lines. Common errors in marking answers include: circling answers, not filling in the entire circle, leaving a blank spot at the center of the circle, or shading too lightly.

2. Erase all stray marks fully.
   Students must use new erasers to achieve a clean erasure. Any residue from the eraser or any dark

smudge left after the erasure may cause the answer to be scored as incorrect because the scanner reads this as two choices being picked.

3. Complete ID numbers correctly.
   Sometimes students fill in an ID number incorrectly or in the wrong place. This leads to some confusion in the grade reports. For example, the student may be included in the wrong class report.

4. Right justify ID information.
   Some students fail to right justify ID information. For example, if a class number is 6, it should be entered with leading zeros. Sometimes students enter the digit 6 in the leftmost column, and the computer reads that as a 6 followed by zeros. This can lead to the student being included in the wrong class report. A lack of clarity also occurs when a student incorrectly enters the date March 2nd and it is read as March 20th.

5. Fill in the rectangular boxes above the bubbles.
   The ID information bubbles have rectangular boxes above the bubbles for writing in the information by hand. Sometimes students leave these boxes blank. This information is needed because sometimes the bubbles do not scan correctly and some errors are sent to a (human) test scorer to be corrected manually.

Scoring the DT-HSM

The DT-HSM is returned to the publisher for scoring. Instructions for returning the DT-HSM answer sheets are included with each test order. After scoring, the DT-HSM answer sheets are returned to the school for its use, together with the student, class, and school grade reports.

Interpreting the DT-HSM Diagnostic Scores

The DT-HSM diagnostic scores are reported in terms of raw scores. This is done so as not to create an impression of precision which the scores do not support, since most scale scores are based on responses to 2 or 3 questions. So, for example, a student report might indicate that the student correctly answered 0 of the 3 questions on whole numbers. This would indicate an area of weakness. Anything less than a perfect score indicates an area of possible weakness. Norms are provided for these scores (see Chapter 5).

Number of Questions Not Attempted

The reports indicate the number of questions left blank. This may provide information about the speed with which a student can answer these types of questions or the confidence of the student to fill in answers. Norms are provided for this score (see Chapter 5). Only in extreme cases will this score be of great use.

Percent Correct of Questions Attempted

The reports indicate the percent correct for only the questions attempted. This may provide information about the student's test taking strategy, such as the willingness of a student to guess. Norms are provided for this score (see Chapter 5). Only in extreme cases will this score be of great use.

Interpreting the DT-HSM Total Score

The reports give the total score for all competency areas, again in terms of a raw score. The highest possible score is 60. Norms are provided for this score (see Chapter 5).

Setting Passing Points on the DT-HSM

Sometimes it is necessary for organizations to set an operational passing point for practical reasons, as when selecting students for an advanced math course. This can pose a dilemma. There is no magic number above which students will be able to do the course work and below which students will not. Rather, as the passing point is set higher, a higher proportion of the students selected will be successful. Unfortunately, with higher passing points, more students will be rejected who would have been able to handle the course work successfully. Setting passing scores is a sensitive matter and expert advice may be needed if this is to be done. In some instances it may be reasonable to make class assignment decisions based solely on scale scores. In other circumstances class assignment decisions may more reasonably be made based on scale scores together with other information the school may have about the students.

Reporting DT-HSM Results to Students and Parents

When used for diagnostic purposes, we recommend that students be given a copy of their student report and counseled that additional curriculum material is available to help them in areas of weakness. The student reports explain that the diagnostic scores are only an indication of their strengths and weaknesses, since they are based on only 2 or 3 questions for each competency area. One way to structure the reporting of DT-HSM scores is to hold a meeting for both students and parents in which topics are covered such as: the goals of the diagnostic testing, the nature of the diagnostic scores, the limits of this type of testing in general, and the steps which may be taken to address the skill deficits revealed by the test.

When used for placement purposes, we recommend that no student be told that he or she has "failed" the test. Rather, we suggest that students be told that they did not score well overall and in certain areas.

Ordering Information and Prices for the DT-HSM

The DT-HSM is distributed and scored by:

APR Testing Services
27 Judith Road
Newton, MA 02459
(617) 244-7405
E-mail: Support@APRTestingServices.com

Pricing information is available on-line at: http://www.aprtestingservices.com/educational. The prices include test booklets, answer sheets, and scoring. The turnaround time for grading is typically under two weeks.

Chapter 3. Development of the DT-HSM

During the development of the DT-HSM, two fundamental issues were addressed: (1) determining the competencies covered in the 10th grade statewide math test given in Massachusetts (the MCAS), and (2) developing a relatively short test which would measure these competencies.

The purpose of the test was twofold: (a) to provide a measure of knowledge in various areas of high school math, and (b) to provide an overall score predictive of future performance in math courses. For diagnostic purposes, this test is intended to be used on an absolute basis: either the student has or has not mastered certain material. For placement purposes, the test may be used on a normative basis, to identify those students in a group with stronger math preparation and competence.

First the method used to identify the test areas and test format is described, and then the development of the test questions is described.

Identifying Test Content

This test was intended, in part, to help teachers and administrators prepare students in all the areas needed to be successful on statewide math examinations, and specifically the Massachusetts examination (the MCAS). Several sources were reviewed to identify the competency areas for the DT-HSM. First, several textbooks were reviewed. The content of the MCAS was then systematically analyzed (as described below) and competency areas identified. The competencies required by some other statewide testing programs were reviewed also, but less systematically. Finally, discussions were held with a number of math teachers and math tutors concerning the tentative test areas, and refinement of the material undertaken as needed.

Competencies Required by the MCAS

The MCAS is a Massachusetts statewide testing program of the type in use in most states. A fundamental goal of the Massachusetts Education Reform Act is to raise expectations and promote high standards for all the students of the Commonwealth. Although the MCAS publications list test areas, called "learning standards," some are rather broadly described. For example, one learning standard is to "use patterns and functions to represent and solve problems" and another is to "create and apply number theory concepts, including prime numbers, factors, and multiples" (Massachusetts Department of Education, 1999, pages 144-145). To identify the competencies required by the MCAS, we reviewed the list of learning standards. We also examined each question which appeared on the 10th grade mathematics section of the MCAS tests (released questions for May 1998, Spring 1999, Spring 2000, and Spring 2001).

The test questions for these four sets of MCAS 10th Grade Math released questions (1998, 1999, 2000, and 2001) were classified into 20 competency areas as listed in Table 1 (see Chapter 1). Each question on these four released MCAS tests was classified as requiring one or more of the 20 competencies. One MCAS question might require several competencies. The number of MCAS questions requiring each competency is summarized in Table 2. Descriptions of the 20 competency areas are given in Table 3.

Table 2. Percent of MCAS Questions Using Each Competency: Grade 10 Math

Subject/Competency Area	%	Subject/Competency Area	%
1. Whole Numbers	17.25	11. Graphs	5.33
2. Common Fractions	3.21	12. Tables	3.48
3. Decimal Fractions	3.74	13. Estimation	2.37
4. Percentages	2.74	14. Probability	2.03
5. Signed Numbers	2.69	15. Statistics	2.09
6. Powers and Roots	3.97	16. Order of Operations	4.60
7. Substitution	2.94	17. Ratios	0.86
8. Setting up Equations	7.75	18. Math Vocabulary	4.51
9. Algebra Equations	6.60	19. Word Problems	12.81
10. Geometry	8.85	20. Miscellaneous	2.19

Note: This table reflects analysis of the May 1998, Spring 1999, Spring 2000, and Spring 2001 released questions. The total of these entries is greater than the number of released questions because many questions were linked to more than one competency.

Table 3: Competencies Needed for Grade 10 MCAS Math Questions	
Subject Area	**Description**
1. Whole Numbers	Add, subtract, multiply, and divide whole numbers; including carrying, borrowing, and saving a place with a zero.
2. Common Fractions	Add, subtract, multiply, divide, and reduce common fractions and mixed numbers; including finding common denominators.
3. Decimal Fractions	Add, subtract, multiply, divide, and convert decimal fractions into common fractions and percentages (including multiplying and dividing numbers by 10 and powers of ten).
4. Percents	Add, subtract, multiply, and divide percentages, and convert percentages into common and decimal fractions; determine X percent of a given number; determine what percent X is of a given number; relate percentages to a whole (e.g., 110% is more than 1 unit).
5. Signed Numbers	Add, subtract, multiply, and divide signed numbers.
6. Powers and Roots	Work with and solve equations containing powers and roots, including use of the laws of exponents.
7. Substitution	Substitute values for unknowns in an expression or equation.
8. Setting up Equations	Set up an equation or series of equations when given information in the form of a word problem or a data chart.
9. Solving Algebraic Equations	Solve one equation with one unknown, and two equations with two unknowns; solve quadratic equations using factoring; simplify and isolate variables to find the solution (without using the "guess and check" method).
10. Geometry	Have knowledge of and be able to work with points, angles, parallel lines, lines of symmetry, surfaces, vertices, different types of triangles, similar figures, Pi, the Pythagorean theorem; find the area and perimeter or circumference of basic shapes; solve problems involving inscribed and circumscribed polygons and circles; know properties of common triangles (e.g., 3/4/5 and 45°/45°/90°).

Chart 3: Competencies Needed for Grade 10 MCAS Math Questions (continued)	
Subject Area	**Description**
11. Graphs	Understand common types of graphs (Cartesian, bar, pictograph, scatter, pie), read axes and their scales; find and chart points using X and Y coordinates; reflect, rotate, and translate figures across axes; write the equation of a line when given the graph of the line, two points on the line, or the slope and a point on the line; interpret a graph; graph a line and extrapolate values; write an equation for the approximate line-of-best-fit for several data points; know the notation for the four quadrants; construct a graph from given tabular or narrative data; use information in a key.
12. Tables	Understand how row and column titles correspond to data inside a table, find pertinent information in a table and transfer the information to a graph, be able to match data in a table with graphical representations and written equations, extrapolate from data in a table.
13. Estimation	Know when and how to use estimation, round and estimate to check answers.
14. Probability	Find the probability of an event based on a narrative description or tabular data, make reasonable predictions using probability, calculate odds, find the probability of the occurrence of two independent events
15. Statistics	Know how to find and interpret the mean, median, mode, and range of a data set; work backwards using the equation for the average (e.g., find the sum from the mean and N); recognize and be able to work with box plots (box-and-whisker graph) and stem and leaf plots.
16. Order of Operations	Understand order of operations; know and apply PEMDAS (Parentheses, Exponents, Multiplication, Division, Addition, Subtraction).
17. Ratios and Proportions	Represent data in ratio form and set up ratio problems; add, subtract, multiply, divide, and reduce ratios (including attention to units); understand difference between and be able to convert between ratios and proportions.
18. Math Vocabulary	Know words like numerator, denominator, product, sum, meter, reciprocal, absolute value, irrational number, integer, origin, real number and prime number; know geometry vocabulary such as equilateral triangle, congruent, and perpendicular.

Chart 3: Competencies Needed for Grade 10 MCAS Math Questions (continued)	
Subject Area	**Description**
19. Word Problems	Understand written and diagramed scenarios, translate word problems into equations, discern what information is necessary to solve the problem and what information is superfluous.
20. Misc.	Convert between units of measure, calculate the nth term in a data series, solve basic trigonometry problems, solve and graph simple inequalities, be familiar with the notation f(x) = , perform simple matrix arithmetic operations.

Rationale for the Choice of a Multiple-Choice Format

The multiple-choice format was chosen based on several considerations, primarily for ease of grading and economy of testing time. Since there are 20 competency areas identified, testing time was a major concern. Typically, one constructs a test with 10 or more questions to measure a competency. However, that would result in a test with over 200 questions, and it was thought such a test would be too long to be practical for most users. The decision was made to use multiple choice questions with 10 choices for two reasons. First it would reduce the score which would be expected based on guessing. Second it would reduce the feasibility of "working questions backward" (i.e., trying each answer to see if it satisfies the conditions of the question).

Writing Test Questions

Several goals guided the writing of the test questions. First, each question should be a substantive test of the competency area being tested. Second, each question should be a rather pure test of the competency, minimizing reliance on knowledge of other areas. Third, the two or three questions for a competency should cover major parts of the competency. Fourth, the subject matter of the word problems should be familiar to most or all students and avoid areas which may be culturally biased. (This is consistent with the spirit of the Civil Rights Act of 1964.) Fifth, the grammar, syntax, and vocabulary used was kept simple and straightforward, thereby avoiding entangling ("confounding") measurement of math with measurement of English.

Difficulty Level of Questions

In writing the questions to reflect the range of the competency areas, we avoided writing unrealistically difficult questions. This was done so that the test would identify students who lacked even basic knowledge of a competency area. Each competency area was tested with at least two questions and most with three. The first question in each area was written to be relatively easy.

Question Sequence

The questions were arranged so that even if a student only finishes half the test, at least some information will still be available for all competencies. The first 20 questions cover each of the 20 competencies. The next 20 questions ask a second question for each competency area. The remaining questions cover the areas which have 3 questions. So the first question measures use of whole numbers, the 19th question measures word problems, the 21st question begins the second set with a question on whole numbers, and so forth.

Randomized Answer Key

After the questions were written, the correct answer was assigned to one of the 10 answer choices using a table of random numbers, subject to the constraint that every choice be used about an equal

number of times.

Review, Piloting, and Revision of Questions and Competencies

At several points during its development, the DT-HSM was reviewed by diverse subject matter experts (teachers, counselors, mathematicians, psychometricians) from diverse backgrounds (including both public and private schools). The competency areas were reviewed for clarity and accuracy. Student feedback on the test questions was collected on early versions of the test by simply asking students to comment while taking the test. Based on these reviews, some questions were edited and others added to improve clarity and exhaustiveness. The questions were pilot tested prior to field use.

An Evaluation of the 10 Choice Test Question Format

It is unusual to offer students 10 choices, but research on a pre-algebra test with 15 choices showed that none of the anticipated problems materialized, and the response format was practical as well as utilitarian (Wiesen, 2002).

Using the DT-HSM as a Power Versus a Speed Test

When the DT-HSM is given in 90 minutes, there should be enough time for most students to complete the test, making it more of a power rather than a speed test. You may also give the test without a time limit.

We suggest that the time allowed for the DT-HSM be consistent within a school district. Scores for students who took the test with different time limits are not directly comparable.

Scoring Methodology

The scores all represent the number of questions answered correctly unless a percentage is reported (as in the total score).

Professional Test Development Standards

In the development of this test, we have tried to conform to the high standards and ideals embodied in the *Standards for Educational and Psychological Testing* (AERA, APA & NCME, 1999).

Chapter 4. Reliability and Validity of the DT-HSM

The reliability of the DT-HSM may be considered overall and for each diagnostic area. Both approaches are reported here. The validity of the DT-HSM is addressed using content validation.

Reliability of the Total Score

To date, a total of 1,138 students from three school districts in Massachusetts and one in Texas have taken the DT-HSM. The reliability of the total score is .89 (Cronbach's alpha). (See Table 4.) This is respectable overall reliability for a test, and is especially high given the diverse content of this test. This level of reliability is certainly high enough for the intended purpose of the total score: to assess the total level of preparation of individual students or groups of students.

Table 4. Reliability of the DT-HSM Total Score

Score Description	Reliability*	Sample Size
Total Score	0.89	1,138

* Cronbach's alpha

Reliability of the Competency Area Scores

The median reliability for the competency area scores is .23 and the arithmetic mean (a conservative estimate) is .27. This level of reliability is high considering the small number of questions in each area (usually 3), and is high enough for the intended purposes for the competency area scores, which are: (1) to serve as an initial quick screen for individual students to suggest areas for more study and more extensive testing, and (2) to assess the strengths and weaknesses of groups of students. The reliability of the total score is high enough for more important individual decisions, such as class placement.

The correlations between the area scores and the score on the remainder of the test have a mean correlation of .50 (see Table 5). This indicates that the various area scores reflect both knowledge of the various specific areas and also a general math knowledge.

The item-total correlations range from .54 to -.01 and average .35, with 39 of the question-total correlations being over .3 and only 1 below zero.

Finally the intercorrelations of the 20 area scores have a range from .088 to .431 with a mean

of 0.28 (based on data from the same 1,138 students). The competency area score intercorrelation matrix is given in Appendix A.

Table 5. Correlation of DT-HSM Competency Area Scores with the Rest of the Test

Competency Area*	r**	Competency Area*	r**
1.Whole Numbers (2)	0.36	11. Graphs (3)	0.51
2. Common Fractions (3)	0.58	12. Tables (3)	0.41
3. Decimal Fractions (3)	0.54	13. Estimation (3)	0.55
4. Percentages (3)	0.42	14. Probability (3)	0.58
5. Signed Numbers (3)	0.59	15. Statistics (3)	0.49
6. Powers and Roots (3)	0.39	16. Order of Operations (3)	0.54
7. Substitution (2)	0.55	17. Ratios (3)	0.56
8. Setting Up Equations (3)	0.42	18. Math Vocabulary (3)	0.55
9. Solving Algebraic Equations (3)	0.53	19. Word Problems (3)	0.41
10. Geometry (3)	0.52	20. Miscellaneous (5)	0.48

Note: All correlations are statistically significant at the p = .01 level.
* The number of questions in each area is given in parentheses after the area name.
** The correlation is between the area score and the score for the test questions for all other areas.

Content Validity of the DT-HSM

The validity of the DT-HSM was initially approached using content validation, which is a widely used approach for test development. The content validation approach involves several key steps: (a) determine the content areas of the test, (b) develop the test to measure these content areas, (c) develop the test so that the questions are a good sample of each content area tested, and (d) minimize measurement of areas not needed (such as unnecessarily hard vocabulary). The steps taken to support the content validity of the DT-HSM are described in Chapter 3. The content validity of the DT-HSM for the Massachusetts statewide examination (MCAS) is particularly supported by the test development work described in Chapter 3. The content validity for the statewide math tests used by other states should be determined on a state by state basis.

Criterion Validity of the DT-HSM

No criterion-related validity studies of the DT-HSM have been completed to date. We are actively seeking research partners for such research and offer use of the DT-HSM at half price for schools offering to share appropriate data (such as course grades or scores on statewide math tests).

Construct Validity of the DT-HSM

No construct validity studies of the DT-HSM have been completed to date. We are actively seeking research partners for such research and offer use of the DT-HSM at half price for schools offering to share appropriate data (such as scores on other math tests).

Future Research

Additional research is possible which would contribute to the understanding of the DT-HSM scores. For example, research might evaluate the correlation of the DT-HSM with:

- Course grades
- Grades on other math tests
- Grades on the state administered MCAS
- Grades on the math tests of other states.

Chapter 5. Normative Data for the DT-HSM

Some users may want to compare their students to students at other schools, while other users may want to use local norms. The DT-HSM may be used in either way. School norms may be developed when candidate groups are large enough. (Candidate groups of 100 or more are large enough.) This chapter presents scores from several schools, including all data available to date.

The means and standard deviations for each of the scales on the DT-HSM are presented in Table 6. This is based on data from four school districts which administered the DT-HSM. The tests were administered in calendar years 2000 and 2003. The means seem low and we expect them to rise as more data becomes available.

Additional normative data is expected to be available soon. Contact the test publisher for the latest norm tables.

What is an Acceptable Score?

What score will be considered acceptable or high will depend on the intended use of the diagnostic information. The norm tables provide some guidance. However, if a student gets less than half the questions correct there is reason to suggest additional remedial education in that area.

Table 6. Descriptive Statistics for the DT-HSM Scales				
Competency Area	**Raw Score Mean**	**Raw Score S.D.**	**% Mean***	**% S.D.**
Total Score (60)**	19.35	8.66	32.3	14.4
1. Whole Numbers (2)	1.57	0.60	78.7	30.1
2. Common Fractions (3)	0.86	0.81	28.7	27.1
3. Decimal Fractions (3)	1.50	0.86	50.0	28.8
4. Percentages (3)	0.99	0.92	32.8	30.6
5. Signed Numbers (3)	0.86	0.83	28.7	27.7
6. Powers and Roots (3)	0.30	0.56	10.1	18.6
7. Substitution (2)	1.20	0.72	60.2	36.1
8. Setting Up Equations (3)	1.08	0.76	36.1	25.2
9. Solving Algebraic Equations (3)	0.61	0.74	20.2	24.5
10. Geometry (3)	1.03	0.74	34.5	24.7
11. Graphs (3)	0.59	0.74	19.8	24.5
12. Tables (3)	1.62	0.68	54.1	22.7
13. Estimation (3)	1.34	0.80	44.7	26.7
14. Probability (3)	0.87	0.75	29.1	24.8
15. Statistics (3)	0.96	0.72	32.0	23.9
16.Order of Operations (3)	1.00	1.01	33.4	33.6
17. Ratios(3)	0.91	0.80	30.4	26.5
18. Math Vocabulary (3)	0.57	0.76	19.1	25.4
19. Word Problems (3)	0.50	0.65	16.6	21.8
20. Miscellaneous (5)	0.96	0.77	19.1	15.5

* % Mean is the mean of the % correct. (N = 1,138)

** The number of questions in each area is given in parentheses after the area name.

References

AERA, APA & NCME (1999) *Standards for Educational and Psychological Testing* (6th ed.) Washington: AERA.

Massachusetts Department of Education (1998) *The Massachusetts Comprehensive Assessment System: Release of May 1998 Test Items.* Malden, Massachusetts: Author.

Massachusetts Department of Education (1999) *The Massachusetts Comprehensive Assessment System: Release of Spring 1999 Test Items.* Malden, Massachusetts: Author.

Massachusetts Department of Education (2000) *The Massachusetts Comprehensive Assessment System: Release of Spring 2000 Test Items.* Malden, Massachusetts: Author.

Massachusetts Department of Education (2001) *The Massachusetts Comprehensive Assessment System: Release of Spring 2001 Test Items.* Malden, Massachusetts: Author.

The Civil Rights Act of 1964, 42 U.S. C. S2000e (1964).

Wiesen, J.P. (2002) *Technical Manual For The Diagnostic Test for Pre-Algebra Math (DT-PAM).* Newton, MA: Applied Personnel Research.

Appendix A: Intercorrelation of Competency Area Scores

Appendix A: Intercorrelation of Area Scores

	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7	Area 8	Area 9	Area 10	Area 11	Area 12	Area 13	Area 14	Area 15	Area 16	Area 17	Area 18	Area 19	Area 20
Area 1	1	.283	.259	.163	.272	.174	.277	.182	.205	.232	.144	.151	.245	.199	.264	.177	.176	.190	.129	.231
Area 2	.283	1	.359	.279	.431	.321	.335	.244	.365	.314	.348	.221	.330	.391	.312	.386	.308	.380	.284	.288
Area 3	.259	.359	1	.283	.404	.223	.311	.286	.294	.284	.263	.297	.392	.309	.283	.353	.355	.310	.242	.285
Area 4	.163	.279	.283	1	.271	.151	.263	.218	.218	.238	.241	.224	.280	.262	.204	.224	.282	.270	.210	.228
Area 5	.272	.431	.404	.271	1	.325	.364	.251	.350	.301	.328	.227	.395	.366	.306	.394	.334	.378	.246	.327
Area 6	.174	.321	.223	.151	.325	1	.234	.158	.237	.224	.231	.088	.247	.285	.199	.284	.208	.320	.132	.172
Area 7	.277	.335	.311	.263	.364	.234	1	.289	.316	.378	.316	.274	.347	.368	.330	.336	.308	.303	.290	.286
Area 8	.182	.244	.286	.218	.251	.158	.289	1	.294	.307	.219	.206	.267	.259	.271	.213	.253	.233	.190	.244
Area 9	.205	.365	.294	.218	.350	.237	.316	.294	1	.325	.331	.228	.280	.368	.320	.295	.349	.336	.305	.277
Area 10	.232	.314	.284	.238	.301	.224	.378	.307	.325	1	.363	.244	.337	.339	.314	.295	.297	.301	.225	.313
Area 11	.144	.348	.263	.241	.328	.231	.316	.219	.331	.363	1	.243	.292	.358	.282	.288	.374	.360	.236	.254
Area 12	.151	.221	.297	.224	.227	.088	.274	.206	.228	.244	.243	1	.309	.222	.232	.260	.332	.219	.188	.257
Area 13	.245	.330	.392	.280	.395	.247	.347	.267	.280	.337	.292	.309	1	.341	.238	.358	.349	.308	.260	.336
Area 14	.199	.391	.309	.262	.366	.285	.368	.259	.368	.339	.358	.222	.341	1	.334	.379	.382	.399	.262	.326
Area 15	.264	.312	.283	.204	.306	.199	.330	.271	.320	.314	.282	.232	.238	.334	1	.284	.368	.296	.241	.250
Area 16	.177	.386	.353	.224	.394	.284	.336	.213	.295	.295	.288	.260	.358	.379	.284	1	.316	.402	.232	.327
Area 17	.176	.308	.355	.282	.334	.208	.308	.253	.349	.297	.374	.332	.349	.382	.368	.316	1	.376	.305	.313
Area 18	.190	.380	.310	.270	.378	.320	.303	.233	.336	.301	.360	.219	.308	.399	.296	.402	.376	1	.262	.267
Area 19	.129	.284	.242	.210	.246	.132	.290	.190	.305	.225	.236	.188	.260	.262	.241	.232	.305	.262	1	.208
Area 20	.231	.288	.285	.228	.327	.172	.286	.244	.277	.313	.254	.257	.336	.326	.250	.327	.313	.267	.208	1

Note: All correlations are based on 1,138 students and are significant at the 0.01 level (2-tailed).