A Comparison of the Massachusetts Comprehensive Assessment System and ACCUPLACER

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Introduction

The purpose of this review is to evaluate equivalence between two testing programs: Massachusetts Comprehensive Assessment System (MCAS) and ACCUPLACER. For each program, only a subset of the tests will be considered: For MCAS, the English Language Arts (ELA) test and Mathematics test, and for ACCUPLACER, the Reading Comprehension test, Sentence Skills test, Arithmetic test, Elementary Algebra test, and College-Level Mathematics test. These two sets have many differences and as a result, comparing them poses several challenges, some of which are addressed here and some of which lie beyond the scope of this review. This review is based exclusively on materials published or provided by the test developers. It is neither exhaustive nor definitive but it provides a general indication of the similarity between the two instruments.

To evaluate the similarity of multiple instruments, the substance, depth, range, and representation of the content must be compared. Provided that the content of the two tests are determined to be comparable, the issue of score comparison can be addressed. However, if the two instruments differ too greatly in terms of content representation, the issue of score comparability is meaningless, and the instruments cannot be treated interchangeably. The degree of equivalence—i.e., similarity—required depends entirely on the intended use of the scores. In a high stakes testing situation, such as high school graduation or college admissions, the content on each test and the mastery represented by success on each test should be highly similar if important decisions are to be based on the assumption that the assessments are interchangeable. To determine the extent to which scores on the MCAS tests and the ACCUPLACER tests are interchangeable, the test content and the abilities possessed by examinees performing at given proficiency levels must be defined for each instrument and then compared. In the case of MCAS, a score of 220 represents a minimum passing score, and as such will be used as the proficiency level of interest.

This review is organized as follows: First, an approach to comparing test content (*content equivalence*) is outlined. Following this description is an explanation of the approach used to compare abilities associated with various proficiency levels (*cut-score equivalence*). Then, using these two methods, a comparison of the MCAS ELA test with the ACCUPLACER Reading Comprehension and Sentence Skills tests, and a comparison of the MCAS Mathematics test with the ACCUPLACER Arithmetic, Elementary Algebra, and College-Level Mathematics tests is provided. (Incidentally, although the analyses of the MCAS ELA and Mathematics tests are structured similarly, they nonetheless vary considerably. This is due to the substantially different treatment of these content areas by the Massachusetts Department of Education [MDOE].) The review ends with a brief summary and a few remarks.

Content Equivalence

Evaluating test content at the item level requires subject matter experts and other resources not available for this review. Instead, comparison of test content was based on an analysis of the content as described by the Massachusetts Department of Education, which oversees MCAS, and the College Board, which is responsible for ACCUPLACER. The information provided by these organizations varies considerably in format and depth and it should be noted that its accuracy has not been independently verified as part of this review.

The concept of content equivalence, as it is used in this review, must be clearly understood in order to effectively interpret the results. Oftentimes, proficiency with certain content requires familiarity with more fundamental content (e.g., *grammar* content assumes a degree of competency in *reading*). When a test intends to measure proficiency with some given content, an assumption is made that candidates have sufficient ability with the relevant, more fundamental content, which allows the test content of interest to be measured independently. This assumption is certainly idealized and tends not to happen in practice, but, for the purpose of this review, it is assumed that test scores reflect proficiency with only that content that is of interest to the test designers.

This description is somewhat abstract, but, hopefully, it will help to clarify the very concrete problem of quantifying content representation for the purpose of comparison. Proficiency with certain content from one test may be necessary to demonstrate competency on portions of another test intended to measure other abilities. Consider an example at the item level: A given mathematics item requires an examinee to calculate an arithmetic mean. To be sure, this item requires the ability to perform addition, but its *purpose* is to measure the ability to calculate an arithmetic mean. Now, consider a different item, from another instrument, intended to measure addition proficiency—e.g., an addition problem. Clearly, both items require (at least) some degree of mastery of addition for success. Nonetheless, in this review, such items would not constitute (even partly) equivalent content.

This is a critical point because there are numerous instances of incongruous assessment goals that nonetheless assume *some* common skills. For example, although some ability with grammar is necessary for success on both the ACCUPLACER Sentence Skills test and the ELA Literature Strand items, none of the abilities that are *intended* to be measured coincide (i.e., their respective content domains are completely dissimilar). Therefore, it was not considered appropriate to recognize any degree of content equivalence between these two assessments.

The approach used here, to evaluate content equivalence, considers item format to be of critical importance. MCAS uses four item types: multiple-choice, short-answer, open-response, and writing prompt. The relevant ACCUPLACER subtests are comprised exclusively of multiple-choice items (ACCUPLACER does offer a constructed-response format composition test, WritePlacer Plus, however, it is not included in this review). Multiple-choice items are sometimes referred to as selected-response items because examinees are given multiple answers from which they select one. The other item formats, which only appear here on the MCAS exams, require constructed-responses (i.e., examinee-generated responses). Such items can introduce some disadvantages (e.g., less precision in measurement, more costly to score), but it is believed that these items assess abilities that are not easily or effectively measured using selected-response items. Thus, for the purpose of all quantitative analyses, examinee-generated responses were assumed to measure abilities that cannot be measured effectively with multiple-choice items. However, although not quantified, content similarities between selected-response items and constructed response items are noted as appropriate.

Interpreting item format in this fashion has significant implications for the potential degree of equivalence between the two instruments. Table 1 shows the percent of each item format on the tests being evaluated.

Table 1

Item Format Representation							
	MCAS		ACCUPLACER				
Item Format	ELA	Mathematics	Reading Comprehension	Sentence Skills	Arithmetic	Elementary Algebra	College-Level Mathematics
Multiple-Choice	50	53	100	100	100	100	100
Short-Answer	0	7	0	0	0	0	0
Open-Response	22	40	0	0	0	0	0
Writing Prompt	28	0	0	0	0	0	0
Total	100	100	100	100	100	100	100

It can be seen that roughly 50% of MCAS consists of constructed-response items. Conversely, as previously noted, the ACCUPLACER tests consist entirely of multiple-choice items. Within the framework defined here, 50% of an examinee's scores on MCAS reflect abilities that are not measured by the ACCUPLACER tests. This point is considered in more detail below.

The method used for evaluating content equivalence is loosely based on Webb's (1999) research on alignment. He identifies four characteristics of content: *categorical concurrence*, *depth-of-knowledge consistency*, *range-of-knowledge correspondence*, and *balance of representation*.[1]

One aspect of content equivalence is determining whether both instruments address the same general content areas. Categorical concurrence is used here as a very general indicator of content similarity at the macroscopic level. Two tests may have categorical concurrence but still require levels of understanding that vary in complexity. Depth-of-knowledge consistency refers the degree of similarity between the cognitive demands of the different instruments with respect to the categorically concurrent content areas. Range-of-knowledge correspondence describes the degree of similarity in the breadth of the content domains being measured. And, lastly, one must consider the degree of emphasis given to content areas on each instrument. Balance of representation refers to the weight (i.e., the emphasis, as reflected in the test scores, of a given content area) placed by each exam on the various content areas. The distinction between these four indices is at times somewhat vague and largely a matter of semantics, but it is hoped that using them will help structure content comparisons and add clarity.

Cut-Score Equivalence

For MCAS, the minimum passing score (220) is the cut-score of interest. This review considers how well the levels of competency (and associated abilities) represented by this score, are represented by certain scores on the ACCUPLACER tests. Each testing organization provides descriptions of the abilities associated with various score ranges (proficiency levels) and these descriptions are the basis for the comparisons.

Comparing competencies, as measured by the relevant ACCUPLACER tests and the MCAS tests, is somewhat frustrated by different approaches to defining these competencies. ACCUPLACER and MCAS define their respective proficiency levels from disparate philosophical perspectives. In general, ACCUPLACER tends to describe levels of proficiency by associating *different* abilities, of varying sophistication, with various scores; whereas MCAS tends to describe levels of proficiency by associating different degrees of mastery, with respect to the *same* abilities, with various scores. The example in Table 2 below illustrates these two approaches.

Table 2

An Example of Different Approaches to Defining Ability				
From MCAS Mathematics Proficiency Descriptions			From ACCUPLACER Arithmetic Proficiency Descriptions	
220-239	240-259		about 90	about 112
• demonstrates partial understanding of our numeration system • performs some calculations and estimations • identifies examples of basic math concepts • reads and constructs graphs, tables, and charts • applies learned procedures to solve routine problems • applies some reasoning methods to solve simple problems • identifies and uses basic mathematical terms	• demonstrates solid understanding of our numeration system • performs most calculations and estimations • defines concepts and generates examples and counterexamples of concepts • represents data and mathematical relationships in multiple forms (e.g., equations, graphs) • applies learned procedures and mathematical concepts to solve a variety of problems, including multi-step problems • uses a variety of reasoning methods to solve problems • explains steps and procedures • uses various forms of representation (e.g., text, graphs, symbols) to illustrate steps to a solution		• estimate[s] products and squares of decimals and square roots of whole numbers and decimals • solve[s] simple percent problems of the form p% of ?=r and ?% of q=r • divide[s] whole numbers by decimals and fractions • solve[s] simple word problems involving fractions, ratio, percent increase and decrease, and area	• find[s] equivalent forms of fractions • estimate[s] computations involving fractions • solve[s] simple percent problems of the form p% of ?=r • solve[s] word problems involving the manipulation of units of measurement • solve[s] complex word problems involving percent, average, and proportional reasoning • find[s] the square root of decimal numbers • solve[s] simple number sentences involving a variable

Note that MCAS tends to describe essentially the *same* skills, but with increased mastery, to illustrate higher proficiency levels. With ACCUPLACER, on the other hand, the abilities detailed in successive proficiency categories tend to be somewhat *different* and illustrate higher proficiency levels by being increasingly complex. Because the two instruments use different approaches in defining the abilities associated with various proficiency levels, comparison of these abilities across tests is complicated somewhat. Given the limited resources available for this report, it was decided that the best method for comparing abilities would be qualitative in nature rather than quantitative. The abilities associated with the *Needs Improvement* competency

level on MCAS were compared with those abilities associated with *whichever* ACCUPLACER proficiency level seemed to provide the best match.[2] This determination was made holistically.

Comparison between the MCAS ELA Test and the ACCUPLACER Reading Comprehension and Sentence Skills Tests with Respect to Content Equivalence

The content domain for each test was determined as follows. For the MCAS ELA test, the content domain was represented by the 18 ELA Learning Standards defined in the *Guide to the Massachusetts Comprehensive Assessment System: English Language Arts* (Massachusetts Department of Education [MDOE], 1998).[3] The Learning Standards represent the complete list of abilities assessed by the MCAS ELA test. Information pertaining to ACCUPLACER content that was available at the time of this review was somewhat less comprehensive than that available for MCAS, making the comparison difficult. For this reason, it was decided that the ACCUPLACER content domains would be defined best using the complete list of abilities associated with every proficiency level for each test (eliminating redundant content where appropriate). It should be noted that the intended purpose of the proficiency level descriptions is to aid in score interpretation not to define test content. Nonetheless, these descriptions appear to provide a better accounting of the content being assessed than was available, and using these abilities to define the content domain resulted in a list that was somewhat comparable to the ELA Learning Standards, which, themselves are more ability descriptions, rather than content descriptions.

Categorical Concurrence

Tables 3 and 4 below describe instances of categorical concurrence between the MCAS ELA test and the ACCUPLACER Reading Comprehension and Sentence Skills tests. Each ELA Learning Standard listed is matched with the relevant corresponding ACCUPLACER content areas (as represented by abilities). Recall that categorical concurrence is meant only as an indicator of general content similarities and should not be interpreted as a gauge of content sophistication or comprehensiveness, which are both discussed separately below (see *depth-of-knowledge consistency* and *range-of-knowledge correspondence*, respectively).

Table 3

Categorical Concurrence Between MCAS ELA Language Strand and ACCUPLACER Sentence Skills Test			
MCAS		ACCUPLACER	
ELA Learning Standard	ELA Language Strand	Reading Comprehension Test	Sentence Skills Test
5	• Students will identify, describe, and apply knowledge of the structure of the English language and standard English conventions for sentence structure, usage, punctuation, capitalization, and spelling.[4]	• *Not Assessed*	• [Students will] correct sentence fragments. • [Students will] manipulate complex verb tenses. • [Students will] correct misplaced modifiers. • [Students will] solve problems that combine grammar and logic. • [Students will] manipulate complex sentences with two or more subordinate clauses. • [Students will] correct problems of syntax and repetitive diction. • [Students will] recognize correct and incorrect linkages of clauses, including problems involving semicolons.

Table 4

Categorical Concurrence Between MCAS ELA Literature Strand and ACCUPLACER Reading Comprehension Test			
MCAS		ACCUPLACER	
ELA Learning Standard	ELA Literature Strand	Reading Comprehension Test[5]	Sentence Skills Test
9	• Students will identify the basic facts and essential ideas in what they have read, heard, or viewed.	• [Students will] recognize the main idea and less central ideas [of a short passage.] • [Students will] identify contradictory or contrasting statements.	• *Not Assessed*
13 12	• Students will identify, analyze, and apply knowledge of the structure, elements, and meaning of nonfiction or informational material and provide evidence from the text to support their understanding. • Students will identify, analyze, and apply knowledge of the structure and elements of fiction and provide evidence from the text to support their understanding.	• [Students will] recognize the organizing principles in a paragraph or passage. • [Students will] recognize relationships between sentences, such as the use of one sentence to illustrate another.	• *Not Assessed*
15 17	• Students will identify and analyze how an author's choice of words appeals to the senses, creates imagery, suggests mood, and sets tone. • Students will interpret the meaning of literary works, nonfiction, films, and media by using different critical lenses and analytic techniques.	• [Students will] extract points that are merely implied. • [Students will] follow moderately complex arguments or speculations. • [Students will] recognize tone. • [Students will] analyze the logic employed by the author in making an argument. • [Students will] answer questions that require them to synthesize information, including gauging point of view and intended audience.	• *Not Assessed*

As can be seen, six (of the 18) ELA Learning Standards have categorical overlap with one of the two ACCUPLACER tests. These six ELA Learning Standards also appear to sufficiently represent *all* of the relevant ACCUPLACER content, at least in the very general sense being considered at present. However, 12 ELA Learning Standards do *not* appear to be measured by the ACCUPLACER subtests. They are detailed in Table 5 below.

Table 5

MCAS ELA Learning Standards *Not* Categorically Concurrent with ACCUPLACER Reading Comprehension or Sentence Skills Content	
ELA Learning Standard	ELA Language Strand
4	Students will acquire and use correctly an advanced reading vocabulary of English words, identifying meanings through an understanding of word relationships.
6	Students will describe and analyze how oral dialects differ from each other in English, how they differ from written standard English, and what role standard American English plays in informal and formal communication.
7	Students will describe and analyze how the English language has developed and been influenced by other languages.
	ELA Literature Strand
8	Students will decode accurately and understand new words encountered in their reading materials, drawing on a variety of strategies as needed, and then use these words accurately in…writing.
10	Students will identify, analyze, and apply knowledge of the characteristics of different genres.
11	Students will identify, analyze, and apply knowledge of theme in literature and provide evidence from the text to support their understanding.
14	Students will identify, analyze, and apply knowledge of the structure, elements, and theme of poetry and provide evidence from the text to support their understanding.
16	Students will compare and contrast similar myths and narratives from different cultures and geographic regions.
	ELA Composition Strand
19	Students will write compositions with a clear focus, logically related ideas to develop it, and adequate detail.
20	Students will select and use appropriate genres, modes of reasoning, and speaking styles when writing for different audiences and rhetorical purposes.
21	Students will demonstrate improvement in organization, content, paragraph development, level of detail, style, tone, and word choice (diction) in their compositions after revising them.
22	Students will use knowledge of standard English conventions to edit their writing.

These 12 Learning Standards represent approximately 66%[6] of the ELA assessment. Furthermore, about 11 of the remaining 34%, although seemingly categorically concurrent with the ACCUPLACER content, consist of constructed-response items. Therefore, approximately only 23% of the MCAS ELA test content is categorically concurrent (i.e., similar in a general way) with the ACCUPLACER Reading Comprehension and Sentence Skills content. It follows that the remaining analysis of content equivalence will only be concerned with this 23%.

It is worth noting, however, that the ELA Composition Strand does include some content categorically similar to that on the ACCUPLACER Sentence Skills test, although the decision was made above to not consider these assessments equivalent because of the constructed-response format of the ELA Composition items.

Depth-of-Knowledge Consistency

The categorically concurrent content can be divided into two general content areas: (a) *English language conventions and usage*, which includes ELA Learning Strand 5 and ACCUPLACER Sentence Skills content, and (b) *reading comprehension and interpretation*, which includes ELA Learning Standards 9, 12, 13, 15, and 17, and ACCUPLACER Reading Comprehension content.

Analyzing the data in Tables 3 and 4 above, as expected, the MCAS content descriptions are somewhat more generalized than those for the ACCUPLACER tests. Unfortunately, the more generalized the content descriptions are, the less effectively they indicate depth-of-knowledge, making a comparison of the sophistication of content somewhat problematic. For the purposes of this review, consistency of content sophistication was observed in instances where it seemed reasonably plausible that it *could* exist. These observations should be interpreted cautiously. Bearing this in mind, it appears that, with respect to the English language conventions and usage content, the two instruments measure content similar in complexity.

With the reading comprehension and interpretation content, however, there appears to be some inconsistencies in the depth-of-knowledge measured. The MCAS content gives the impression of placing a greater emphasis on interpretation than does the ACCUPLACER content. *Interpretation* is generally considered more cognitively challenging than *comprehension*. If this is the case, then it would appear that MCAS measures reading comprehension and interpretation content with a greater depth-of-knowledge than ACCUPLACER (this is especially evident with respect to Learning Standards 12, 13, 15, and 17). Furthermore, there is some evidence that the ELA exam uses longer reading passages than the ACCUPLACER tests—although the ACCUPLACER materials are inconsistent with respect to this point. In any event, longer passages are likely to be more cognitively demanding.

There really is no basis for quantifying the "amount" of depth-of-knowledge consistency. A qualitative summary is more appropriate. It should be sufficient to note that the categorically concurrent areas of the tests have *some* equally complex content; but that MCAS probably contains *some* content that is more sophisticated than that on ACCUPLACER.

In this context, depth-of-knowledge consistency *may* not be particularly relevant. The concern here is with content measuring abilities at the *Needs Improvement* performance level. The two tests' content may be of varying complexity, but, provided there is coverage of the content of interest, the depth-of-knowledge *in*consistency is not of particular importance except for its implications for balance of content representation. (Balance of representation is addressed separately below.)

Range-of-Knowledge Correspondence

In evaluating range-of-knowledge correspondence, the same difficulties were present that were encountered analyzing depth-of-knowledge consistency: variation in the representation of content complicates the comparison. Nonetheless, some minor differences can be observed.

MCAS appears to measure a slightly greater range of content than ACCUPLACER. With respect to English language conventions and usage content, the ELA exam measures *spelling*, which is not part of the ACCUPLACER content domain. With respect to the reading comprehension and interpretation content, MCAS appears to (a) use a broader range of reading material than does ACCUPLACER, specifically, it includes poetry, and (b) the ELA Learning Standards state that examinees must apply some of there analytical skills to other media, namely, "films and media." However, regarding this latter point, it does not appear that MCAS actually includes any media that is not text-based.

In conclusion, with respect to the common content of interest, the tests seem to cover a very similar range of content.

Balance of Representation

Considerable variation in balance of representation was observed between the two assessments. Table 6 below quantifies these differences.

Table 6

Balance of Representation Variation Between MCAS ELA Exam and ACCUPLACER Reading Comprehension and Sentence Skills Tests[7]

Content Categories	MCAS ELA Exam (%)	ACCUPLACER Reading Comprehension and Sentence Skills Tests (%)	Weighted ACCUPLACER Reading Comprehension and Sentence Skills Tests (%)
English language conventions and usage	2	50	9
Reading comprehension and interpretation content	21	50	91
Total	23	100	100

It can be seen that there is a substantial content representation imbalance both *across* tests and *within* tests. The content representation imbalance across tests has already been noted: only 23% of the MCAS content is measured by ACCUPLACER. However, it is now also apparent that the proportional representation of content *within* each instrument also differs substantially. Whereas on the ACCUPLACER subtests, the content categories are weighted equally, it can be seen that on the ELA exam, reading comprehension and interpretation content has more than 10 times greater emphasis than the English language conventions and usage content. Weighting the ACCUPLACER content categories to reflect the relative content emphasis of the ELA exam (as shown in the table above) corrects this disparity somewhat (and is quite easily done given that each content category is represented by single test); however, doing so is likely to effect the validity and reliability of the ACCUPLACER assessments in unknown ways.

Comparison between the MCAS ELA Test and the ACCUPLACER Reading Comprehension and Sentence Skills Tests with Respect to Cut-Score Equivalence

With ACCUPLACER we are interested in *whichever* proficiency level is most similar to MCAS's minimum competency proficiency level—i.e., *Needs Improvement*. As outlined above, this determination was made holistically by choosing the ACCUPLACER proficiency category that described those abilities with the greatest similarity to those used by MCAS to describe examinees performing at the *Needs Improvement* level. Outside of the writing assessment, which was not included because of its constructed-response format, none of the abilities demonstrated by the minimally proficient MCAS examinee were similar enough to the abilities demonstrated on the ACCUPLACER Sentence Skills test to justify comparing them.[8] Therefore, only the ACCUPLACER Reading Comprehension abilities were considered here. It was decided that abilities demonstrated by an MCAS ELA score of 220 were most closely represented by an ACCUPLACER Reading Comprehension score of about 80. Table 7 below lists these abilities.

Table 7

Comparison of Competencies		
MCAS ELA Literature Strand		ACCUPLACER Reading Comprehension Test
Abilities of the Examinee Scoring a Minimum of 220		Abilities of the Examinee Scoring about 80
Comprehension	• demonstrates an understanding of concrete ideas, but only partial understanding of abstract or implied ideas in grade-appropriate texts • connects some ideas within texts	• recognize[s] the main ideas and less central ideas [of a short passage] • recognize[s] the tone of the passage when questions do not require fine distinctions • recognize[s] relationships between sentences, such as the use of one sentence to illustrate another • comprehend[s] short passages that are characterized by moderately uncomplicated ideas and organization • answer[s] questions that require [examinees] to synthesize information, including gauging point of view and intended audience view and intended audience • identif[ies] contradictory or contrasting statements
Text Elements and Techniques	• shows partial understanding of how structure and genre enhance the author's purpose or theme • identifies obvious examples of some techniques authors use (e.g., repetition, exaggeration, and figurative language)	• recognize[s] organizing principles in a paragraph or passage

As can be seen, the abilities measured by the two assessments are not equivalent. Nonetheless, there is considerable overlap in some of the skills demonstrated, especially with those abilities related to *Comprehension*. However, there are numerous abilities tested by the MCAS ELA test not measured by any of the ACCUPLACER tests. Table 8 details these abilities.

Table 8

Abilities Demonstrated by the Minimally Competent MCAS ELA Examinee and *Not* Measured by the ACCUPLACER Reading Comprehension Exam	
Language Strand	
Language/Vocabulary	• demonstrates a modest reading vocabulary and partial understanding of word parts and word relationships (e.g., prefixes, roots, suffixes, synonyms, antonyms)
Composition Strand	
Composition	• writes partially organized compositions with modestly developed ideas some supporting detail, and some demonstration of focus • uses simplistic language and sentence structure
Writing Conventions	• writes compositions with partial control of the standard English conventions of grammar, spelling, punctuation, and usage

The Literature Strand comprises 64% of the MCAS ELA score. Twenty-two of this 64% is measured by constructed-response items. Therefore, a maximum of 42% of the MCAS ELA abilities represented by minimum competency (i.e., a score of 220) are also measured by the ACCUPLACER tests. Of course, the abilities demonstrated by the Reading Comprehension test and the ELA Literature Strand are not perfectly aligned, and thus, the actual percent of equivalent competences being demonstrated by an ACCUPLACER Reading Comprehension score of about 80 is no doubt less than 42%. Given the discrepancies in content coverage between the two instruments, this percent could be considerably less—probably about half, if the degree of equivalence of the reading comprehension and interpretation content at this proficiency level is consistent with the degree of equivalence for this content category as a whole.

Comparison between the MCAS Mathematics Test and the ACCUPLACER Arithmetic, Elementary Algebra, and College-Level Mathematics Tests with Respect to Content Equivalence

The content domain for each test was determined as follows. Like the ELA test, the *Guide to the Massachusetts Comprehensive Assessment System: Mathematics* (MDOE, 1998) defined content strands corresponding to the content of the assessment. However, unlike the ELA test, the MCAS Mathematics guide also provides *assessment expectations*, which describe the content coverage with greater specificity. These assessment expectations represent the complete list of abilities assessed by the MCAS Mathematics test. This greater specificity made comparing content easier although it also made it considerably longer than the ELA comparison. With the ACCUPLACER tests, the content was defined in the same manner as it was above: the content domain was defined using the complete list of abilities associated with every proficiency level for each test.

Categorical Concurrence

The MCAS Mathematics test consists of four content strands: (a) *Number Sense*, (b) *Patterns, Relations, and Functions*, (c) *Geometry and Measurement*, and (d) *Statistics and*

Probability. Each strand is then further divided into two or three subtopics (for a total of eleven subtopics), which is then further divided into various assessment expectations (i.e., abilities). Tables 9 through 12 each compare content from one of the MCAS Mathematics content strands to the content on the three ACCUPLACER tests. Comparisons are made at the subtopic level.

Table 9

Categorical Concurrence Between MCAS Number Sense Strand and ACCUPLACER Arithmetic, Elementary Algebra, and College-Level Mathematics Tests			
MCAS	ACCUPLACER		
Number Sense	Arithmetic	Elementary Algebra	College-Level Mathematics
Discrete Mathematics: • use finite graphs to represent and interpret data, e.g., networks, traceable paths, tree diagrams, Venn diagrams, other pictorial representations	• identify data represented by simple graphs	• *Not Assessed*	• *Not Assessed*
Mathematical Structure: • identify and apply concepts of subsets of real numbers, e.g., integers, rational, irrational numbers • use algebraic procedures as they relate to geometric concepts, e.g., create a geometric model for the product of two polynomials	• *Not Assessed*	• [demonstrate] a sense of order relationships and the relative size of signed numbers • combine like terms	• *Not Assessed*
Estimation: • use estimation strategies to determine the reasonableness of results of computations and problems	• estimate products and squares of decimals and square roots of whole numbers and decimals • estimate computations involving fractions	• *Not Assessed*	• *Not Assessed*

Table 10

Categorical Concurrence Between MCAS Patterns, Relations, and Functions Strand and ACCUPLACER Arithmetic, Elementary Algebra, and College-Level Mathematics Tests			
MCAS	ACCUPLACER		
Patterns, Relations, and Functions	Arithmetic	Elementary Algebra	College-Level Mathematics
Algebra: • use variables to formulate and solve problems, e.g., cost formulas, geometric formulas, matrix representations for problems needed to solve systems of equations • simplify algebraic expressions to solve equations and inequalities, e.g., use equivalent expressions in the process of solving equations • solve equations and inequalities • manipulate formulas, equations, and expressions using algebraic procedures • extrapolate and interpolate information from tables and graphs representing equations and inequalities, e.g., applications to spreadsheets	• identify data represented by simple graphs • solve simple number sentences involving a variable	• [able] to multiply a whole number by a binomial • multiply binomials • add radicals, add algebraic fractions, and evaluate algebraic expressions • square binomials • simplify algebraic expressions • solve linear equations with integer, fractional and literal coefficients and linear inequalities with integer coefficients • solve systems of equations • identify graphical properties of equations and inequalities	• solve and graph linear equations and inequalities • understand polynomial functions • evaluate and simplify expressions involving functional notation, including composition of functions • perform algebraic operations and solve equations with complex numbers
Functions: • model real-life situations with graphs on the coordinate plane, e.g., graphs of linear, quadratic, and exponential functions, scatter plots, graphs representing direct and inverse variation • identify and extend patterns and translate them into algebraic functions, e.g., number patterns, geometric patterns, patterns including real-world applications • demonstrate an understanding of the connections between verbal descriptions of functional relationships and input-output tables, equations and inequalities, and graphs on number lines or coordinate planes • use proportional reasoning to solve problems	• solve word problems involving the manipulation of units of measurement • solve complex word problems involving percent, average, and proportional reasoning	• *Not Assessed*	• graph simple parabolas • [demonstrate] a rudimentary understanding of coordinate geometry
Trigonometry: • use sine, cosine, and tangent trigonometric ratios to solve problems involving right triangles	• *Not Assessed*	• *Not Assessed*	• solve right-triangle problems

Table 11

Categorical Concurrence Between MCAS Geometry and Measurement Strand and ACCUPLACER Arithmetic, Elementary Algebra, and College-Level Mathematics Tests			
MCAS	ACCUPLACER		
Geometry and Measurement	Arithmetic	Elementary Algebra	College-Level Mathematics
Geometry and Spatial Sense • *no categorical concurrence* Measurement • *no categorical concurrence* Geometry from an Algebraic Perspective • *no categorical concurrence*			

Table 12

Categorical Concurrence Between MCAS Statistics and Probability Strand and ACCUPLACER Arithmetic, Elementary Algebra, and College-Level Mathematics Tests			
MCAS	ACCUPLACER		
Statistics and Probability	Arithmetic	Elementary Algebra	College-Level Mathematics
Statistics: • analyze data sets to identify and select appropriate measures of central tendency • analyze and interpret data presented in graphs Probability: • *no categorical concurrence*	• calculate an average, given integer values • identify data represented by simple graphs	• *Not Assessed*	• *Not Assessed*

As can be seen, seven of the eleven MCAS subtopics have categorical overlap with at least one of the ACCUPLACER tests. (Of noteworthy interest is the Geometry and Measurement Strand, which has no representation on the ACCUPLACER tests.) These seven subtopics account for 60% of the MCAS Mathematics score.[9] However, 47% of the MCAS Mathematics test consists of constructed-response items. Therefore, it appears that only about 32% of the MCAS content is categorically concurrent (i.e., similar in a general way) with the ACCUPLACER Arithmetic, Elementary Algebra, and College-Level Mathematics content. The remainder of the analysis will be concerned only with this 32%.

Depth-of-Knowledge Consistency

Given the limitations of this review, evaluating depth-of-knowledge consistency was still best done qualitatively, using the same criteria as was used with the ELA content. However, the

inclusion of the assessment expectations adds another level of specificity not available in the previous comparison. Because of this, the observations here are made somewhat more confidently.

Depth-of-knowledge consistency was evaluated at the subtopic level. The content from each test was compared for each of the seven categorically concurrent subtopics. Table 13 below summarizes the results.

Table 13

Depth-of-Knowledge Consistency between MCAS Mathematics Test and ACCUPLACER Arithmetic, Elementary Algebra, and College-Level Mathematics Tests	
MCAS Subtopics	Depth-of-Knowledge Consistency
Number Sense	
• Discrete Mathematics	much more complex on MCAS
• Mathematical Structure	much more complex on MCAS
• Estimation	equally complex on both instruments
Patterns, Relations, and Functions	
• Algebra	equally complex on both instruments
• Functions	somewhat more complex on MCAS
• Trigonometry	equally complex on both instruments
Statistics and Probability	
• Statistics	equally complex on both instruments

It should be noted that some ACCUPLACER content related to the MCAS content strands was excluded from the categorical concurrence tables above because it was not concurrent with the various MCAS subtopics. Had this content been included, the MCAS test probably would not have appeared as sophisticated compared to the ACCUPLACER tests. A similar effect occurs with the range-of-knowledge comparison below. This problem did not arise with the ELA content because all of the ACCUPLACER content was categorically concurrent with the MCAS content. A description of the unique ACCUPLACER content is given in Table 14 below.

Table 14

ACUPLACER Content *Not* Categorically Concurrent with MCAS Mathematics Content
Arithmetic
• perform the basic arithmetic operations of addition, subtraction, multiplication, and division using whole numbers, fractions, decimals, and mixed numbers • make conversions among fractions, decimals, and percents • find equivalent forms of fractions • solve simple percent problems of the form p% of q = ?, ?% of q = r, and p% of ? = r* • find the square root of decimal numbers
Elementary Algebra
• perform operations with signed numbers • factor quadratic expressions in the form $ax^2 + bx + c$, where a = 1 • factor the difference of squares • solve quadratic equations
College-Level Mathematics
• factor polynomial expressions • simplify and perform arithmetic operations with rational expressions, including complex fractions • solve absolute value equations • solve quadratic equations by factoring • understand the relationship between exponents and logarithms and the rules that govern the manipulation of logarithms and exponents • understand trigonometric functions and their inverses* • solve trigonometric equations* • manipulate trigonometric identities* • recognize graphic properties of functions such as absolute value, quadratic, and logarithmic*

Although none of these abilities are specifically mentioned in the MCAS assessment expectations, all of them, except the five that are asterisked (*), are included in the *Massachusetts Mathematics Curriculum Framework* (MDOE, 2000).

Regardless, about two thirds of the relevant MCAS Mathematics content is measured by ACCUPLACER at approximately the same level of complexity. The remaining third is assessed at a higher level of sophistication on MCAS. Recall that this depth-of-knowledge *in*consistency may not be relevant if the relatively complex content not assessed by ACCUPLACER is beyond the ability of the typical *Needs Improvement* examinee.

Range-of-Knowledge Correspondence

The addition of the MCAS assessment expectations to the analysis allows the evaluation of the range-of-knowledge correspondence to be considerably more in-depth than it was for the ELA comparison. Within each categorically concurrent content strand, the range-of-knowledge correspondence was evaluated based on two considerations: (a) the portion of MCAS assessment expectations, within categorically concurrent subtopics, that have at least some common content with ACCUPLACER content, and (b) the degree to which these assessment expectations measure the same range-of-knowledge as the ACCUPLACER content. Table 15 below lists the assessment expectations, within categorically concurrent subtopics, *not* measured by ACCUPLACER, the percent of each subtopic that these assessment expectations represent, the percent of each subtopic that *is* categorically concurrent with the ACCUPLACER content, and

the percent of the entire MCAS Mathematics content that is both categorically concurrent and, at least partly, within the same range-of-knowledge as the ACCUPLACER content.

Table 15

MCAS Mathematics Assessment Expectations, within Categorically Concurrent Subtopics, That Are *Not* Categorically Concurrent with ACCUPLACER Arithmetic, Elementary Algebra, and College-Level Mathematics Content

Assessment Expectations *Not* Measured by ACCUPLACER	Portion of Assessment Expectations *Not* Measured by ACCU-PLACER (%)	Portion of Assessment Expectations Measured by ACCU-PLACER (%)	% of Learning Strand Measured by ACCU-PLACER*	% of MCAS Mathematics Test Measured by ACCU-PLACER*
Number Sense				23
Discrete Mathematics: • identify, extend, and use a variety of sequences, e.g., applications of the Fibonacci sequence to patterns in nature • create, manipulate, and interpret matrices that represent real-life applications, e.g., structure matrices to represent and process inventory data • create and apply recurrence relations, e.g., find each term in a sequence based on the term or terms before it	75	25	22	
Mathematical Structure: • apply properties of real numbers, e.g., inverses, closure, identity, betweeness, density, properties of operations, order of operations • identify and apply properties of other finite systems, e.g., modular systems, 2 x 2 matrices, defined operations	50	50		
Estimation: • use estimation in making or interpreting graphs	50	50		
Patterns, Relations, and Functions				
• *all content categorically concurrent*	0	100	53	
Statistics and Probability				
Statistics: • construct and interpret data displays, e.g., tables, matrices, frequency distributions, stem-and-leaf plots, circle graphs, line plots, box plots, spreadsheets • fit a line to a scatter plot using estimation, determine the equation of the line of best fit, and use the line to make predictions • determine whether a given sample is biased design an experiment/survey involving sampling and analyze data from the experiment/survey	50	50	13	

* These figures account for the constructed-response MCAS items

Notice that although 32% of MCAS content is categorically concurrent with ACCUPLACER content, only 23% of the MCAS content is both categorically concurrent and, at least partly, within the same range-of-knowledge as the ACCUPLACER content. The remainder of this analysis will be concerned only with this 23%.

The other consideration that must be made with respect to the range-of-knowledge correspondence is the degree to which the MCAS assessment expectations measure the same

range-of-knowledge as the ACCUPLACER content. Unlike the previous consideration, this one must be made qualitatively and it is done in a similar fashion as the previous depth-of-knowledge consistency analysis.

Table 16

Range-of-Knowledge Correspondence between MCAS Mathematics Test and ACCUPLACER Arithmetic, Elementary Algebra, and College-Level Mathematics Tests	
MCAS Subtopics	Range-of-Knowledge Correspondence
Number Sense	
• Discrete Mathematics	similar range-of-knowledge on both instruments
• Mathematical Structure	greater range-of-knowledge assessed on MCAS
• Estimation	similar range-of-knowledge on both instruments
Patterns, Relations, and Functions	somewhat greater range-of-knowledge assessed on MCAS
• Algebra	similar range-of-knowledge on both instruments
• Functions	somewhat more complex on MCAS
• Trigonometry	similar range-of-knowledge on both instruments
Statistics and Probability	
• Statistics	similar range-of-knowledge on both instruments

This table indicates that the range-of-knowledge assessed by those MCAS assessment expectations that are categorically concurrent with ACCUPLACER content is generally similar to the range-of-knowledge covered by the relevant ACCUPLACER content.

Balance of Representation

Considerable variation in the balance of representation was observed between the two assessments. As was done above in Table 15, each MCAS assessment expectation was weighted equally within its respective subtopic; each subtopic was weighted equally within its respective content strand; and, each content strand was weighted according to the test designers' specifications. With ACCUPLACER, each ability was weighted equally within each test and each test was weighted equally. To further facilitate comparisons, the ACCUPLACER tests were then combined and treated as *one* test, just as was done with the Reading Comprehension and Sentence Skills tests above in Table 6. Strictly speaking, in practice each ability is not weighted equally. Because ACCUPLACER is a CAT, those abilities illustrative of the given examinee will be disproportionately over-represented in the assessment. This, of course, is one of the primary advantages of CATs; and MCAS actually has a similar advantage: the MCAS *retest* over-represents low-ability content because in so doing, a better measurement of the minimally competent performance is generated. In any event, both pose a similar problem for this analysis. Nonetheless, the method outlined above should be sufficient for this review, which is only attempting to give a general overview of the similarities of the content domains measured by both assessments. Table 17 below quantifies the balance of representation of the relevant content.

Table 17

Balance of Representation Variation between MCAS Mathematics Test and ACCUPLACER Arithmetic, Elementary Algebra, and College-Level Mathematics Tests					
MCAS		ACCUPLACER*			
Subtopics	Mathematics Test (%)	Arithmetic Test (%)	Elementary Algebra Test (%)	College-Level Mathematics Test (%)	Total for All Three ACCUPLACER Tests
Number Sense	4.5	7.2	4.8	0.0	12.0
• Discrete Mathematics	.9	2.4	0.0	0.0	2.4
• Mathematical Structure	1.8	0.0	4.8	0.0	4.8
• Estimation	1.8	4.8	0.0	0.0	4.8
Patterns, Relations, and Functions	15.9	9.6	19.0	14.6	43.2
• Algebra	5.3	4.8	19.0	8.3	32.1
• Functions	5.3	4.8	0.0	4.2	9.0
• Trigonometry	5.3	0.0	0.0	2.1	2.1
Statistics and Probability	2.7	4.8	0.0	0.0	4.8
• Statistics	2.7	4.8	0.0	0.0	4.8
Total (subtopics only)	23	22	24	15	60†

*Recall that for ease of comparison these figures represent percentages of the three tests combined—e.g., the "22" in the Arithmetic test column indicates that 22% of all the content (by weight not quantity) measured by *all three* ACCUPLACER tests is both (a) equivalent with relevant MCAS content, and (b) appears on the Arithmetic test. However, this 22% comprises 66% of the Arithmetic test content.

†The sum of the bottom row (ACCUPLACER tests only) equals 61 instead of 60 due to rounding error.

It can be seen that there is a substantial content representation imbalance both *across* tests and *within* tests. The content representation across tests has already been noted: only 23% of the MCAS Mathematics content is measured by ACCUPLACER. However, it is now also apparent that the proportional representation of content *within* each instrument also differs substantially. For example, the range of the percentages for the subtopics on MCAS is 2.7%-15.9%, whereas the range for ACCUPLACER is 4.8%-43.2%.

Comparison between the MCAS Mathematics Test and the ACCUPLACER Arithmetic, Elementary Algebra, and College-Level Mathematics Tests with Respect to Cut-Score Equivalence

With ACCUPLACER we are interested in *whichever* proficiency level is most similar to MCAS's minimum competency proficiency level—i.e., *Needs Improvement*. As was done with the MCAS ELA test, this determination was made holistically by choosing the ACCUPLACER proficiency category that described abilities with the greatest similarity to those used by MCAS to describe examinees performing at the *Needs Improvement* level. Table 18 compares these competencies. As can been seen in Table 18, the *Needs Improvement* Level corresponds most

closely with a score of 57 on the Arithmetic Test, a score of 57 on the Elementary Algebra Test and a score of 40 on the College-Level Mathematics Test.

Table 18

Comparison of Competencies		
MCAS Mathematics Test		ACCUPLACER Arithmetic Test
Abilities of the Examinee Scoring a Minimum of 220		Abilities of the Examinee Scoring about: 57 on the Arithmetic Test 57 on the Elementary Algebra Test 40 on the College-Level Mathematics Test
Conceptual Understanding and Procedural Knowledge	• demonstrates partial understanding of our numeration system • performs some calculations and estimations • identifies examples of basic math concepts • reads and constructs graphs, tables, and charts	• calculate[s] an average, given integer values • identif[ies] data represented by simple graphs • perform[s] the basic arithmetic operations of addition, subtraction, multiplication, and division using whole numbers, fractions, decimals, and mixed numbers • make conversions among fractions, decimals, and percents • a sense of order relationships and the relative size of signed numbers • the ability to multiply a whole number by a binomial • perform operations with signed numbers • identify common factors
Problem Solving	• applies learned procedures to solve routine problems	• solve[s] simple word problems • combine like terms • multiply binomials • factor binomials and trinomials
Mathematical Reasoning	• applies some reasoning methods to solve simple problems	• solve[s] simple word problems • evaluate algebraic expressions • manipulate factors to simplify complex fractions
Mathematical Communication	• identifies and uses basic mathematical terms	• perform[s] the basic arithmetic operations of addition, subtraction, multiplication, and division using whole numbers, fractions, decimals, and mixed numbers

Clearly, there is considerable overlap in many of the abilities measured by the two assessments—much greater similarity than was found with the ELA test. This is partly due to the fact that there are no ability categories in the MCAS Mathematics proficiency description exclusively dedicated to constructed-response items as there was with the ELA proficiency description (e.g., *Composition*). In any event, it appears as though much of the content disparity between the two instruments may have occurred above the *Needs Improvement* proficiency level. Ignoring the constructed-response items, candidates performing at the *Needs Improvement* level on MCAS seem to be demonstrating quite similar abilities as those examinees performing at the relevant ACCUPLACER proficiency levels. Taking into account the constructed-response items, no more than 53% of the MCAS Mathematics abilities represented by minimum competency (i.e., a score of 220) are also measured by the ACCUPLACER Arithmetic, Elementary Algebra, and College-Level Mathematics tests.

Discussion

Summary

The content measured by the two instruments varies considerably. For both the MCAS ELA and Mathematics tests, it was determined that only 23% of the tests' respective content was also measured by ACCUPLACER. At the proficiency level of interest (*Needs Improvement*), there is somewhat greater content equivalence, at least there appears to be, based on the proficiency level descriptions. This is especially apparent on the Mathematics test and suggests that content differences may be disproportionately represented in content related to proficiency categories other than *Needs Improvement*.

A sizeable amount of the content differences must be attributed to the constructed-response items, which account for at least half of the MCAS tests. Even so, there are substantial content differences simply due to variation in the substance, depth, range, and representation of the content.

Remarks

Obviously, additional research is needed to make any observations with confidence, but based on this review, MCAS and ACCUPLACER do not appear to be measuring examinee proficiency with the same content for the majority of the assessment. No doubt, they do, in fact, measure some of the same abilities, however, it is evident that they were not designed to be interchangeable and doing so would have unpredictable effects on the reliability and validity of the results. The MCAS and ACCUPLACER tests appear to differ substantially in content and purpose, and using them interchangeably is not recommended.

References

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Footnotes

[1] Webb uses these terms more as conditions than characteristics. That is, for him, content being compared must either satisfy these conditions or not; whereas in this review, these terms are used more as characteristics, and it is the *degree* to which they are satisfied that is of interest.

[2] For this comparison, it was assumed that any examinee who demonstrates competency at a given ACCUPLACER proficiency level has also mastered the content associated with any lower proficiency level. This is a reasonable assumption, and one implicit in most computer adaptive tests (CATs). However, the adaptive nature of the test form could potentially result in the omission of some content, especially content associated with proficiency levels above or below a candidate's proficiency level (e.g., relatively high ability examinees may not have the opportunity to demonstrate relatively less sophisticated skills). Indeed, this is usually considered one of the benefits of CATs. Nonetheless, such test forms could have unpredicted effects on content coverage. (This is of particular concern with criterion-referenced instruments and content that is not part of a cumulative learning sequence.) Naturally, test designers incorporate content specifications into the item selection algorithms, and it is hoped that such effects are avoided, but it should be noted that ACCUPLACER does not explicitly define their content specifications, which, in any event, undoubtedly differ from those for MCAS.

[3] Other MDOE publications define these standards slightly differently.

[4] Based on the abilities associated with the ELA proficiency levels in the relevant MDOE publications, there is no evidence that the skills described in Learning Standard 5 are actually being assessed on MCAS (except indirectly within the Composition Strand). However, a review of the test items from the Spring 2002 administration of the ELA exam (MDOE, 2002) found three items (out of 40) measuring Learning Standard 5 content, two of which were categorically concurrent with ACCUPLACER content. Perhaps it was believed by the MDOE that these abilities are so fundamental that mastery of them is implicit for even the minimally competent examinee.

[5] It is not clear from the ACCUPLACER materials what type of reading passages are included on the Reading Comprehension test. It was assumed that the test included either fiction or nonfiction passages, but did not include poetry. There was not very much evidence in support of this assumption—or any other—but it seemed the most reasonable based on the little information available.

[6] An assumption is made here—and throughout this review—that the ELA Learning Standards assessed *within* a given content strand were weighted equally.

[7] Two considerations regarding this table should be noted. First, as was done above, an assumption was made that the ELA Learning Standards assessed *within* a given content strand were weighted equally. Second, the ACCUPLACER Reading Comprehension and Sentence Skills tests are treated as a single assessment because, since they are being compared to a single instrument (i.e., the ELA exam), doing so simplifies the comparison.

[8] As briefly mentioned above (see footnote 3), review of the ELA test items suggests that there is, in fact, some content similarity with the ACCUPLACER Sentence Skills test. However, it is beyond the scope of this review to attempt to quantify the abilities demonstrated by minimally competent examinee performance with this content by conducting an item analysis. The cut-score comparisons were therefore based exclusively on the proficiency descriptions of the two tests. The Sentence Skills content appears to be similar with only approximately 2% of the MCAS content so it is unlikely that this inconsistency will significantly affect the results.

[9] Similar to what was done with the ELA Learning Standards, each subtopic was considered equally weighted within its content strand for the calculation of these percentages. Below, the same principle was applied to the abilities within each subtopic: each ability, within a subtopic, was weighted equally.