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A Replication of Static Use of Six Brief Middle School Mathematics Measures

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Abstract

The present study extends initial work on the development of brief mathematics measures for middle school students. Participants included 472 students in Grades 7 and 8. Six brief mathematics measures were investigated, including two measures traditionally used with elementary (Grade 6) students and four measures designed specifically for middle school. All six required short administration times (less than 8 minutes) and would be suitable for both screening and progress monitoring. In addition, Grade 7 students also completed three mathematics screening measures at the beginning of the school year. These district screening tools included two comprehensive measures developed by district teachers (one multiple choice and one constructed response) and a commercial algebra prognosis test. Each of the district screeners required approximately 40-45 minutes for administration. Data from the district's high stakes assessment in mathematics (the Iowa Tests of Basic Skills) were available for all students. Data analyses included examinations of the alternate-form reliability and criterion validity of the progress monitoring measures. Criterion validity was also examined for the district screeners. Regression methods were used to explore the potential use of the measures in combination; discriminant analyses were used to examine the accuracy of predicting which students would pass the high stakes assessment. Results indicated that the district screeners (particularly the algebra measure and the multiple choice measure) had stronger relations with the high stakes assessment than the majority of the progress monitoring measures. Among the progress monitoring measures, the Grade 6 concepts and applications measure produced criterion validity coefficients and classification accuracy results that were similar to the district screeners.

A Replication of Static Use of Six Brief Middle School Mathematics Measures

Background Information

The research on progress monitoring tools in mathematics provides only limited guidance for teachers at the middle school level (Foegen, Jiban, & Deno, 2007). Foegen (2008) described the existing measures that have been used or are currently under investigation for middle school mathematics. Foegen and her colleagues (Foegen, 2000, Foegen & Deno, 2001) have conducted initial research on potential measures involving estimation and basic fact proficiency. In more recent research conducted by the Research Institute on Progress Monitoring, additional measures (Missing Number, Complex Quantity Discrimination) involving numeracy concepts have been explored (Foegen, 2008; Foegen, Klein, Lind, & Jiban, 2008).

Evidence of technical adequacy varies by type of measure. For some measures, such as basic facts and estimation, evidence exists for the measures' technical adequacy as a static measure (necessary for screening) and as an indicator of weekly growth (necessary for progress monitoring). Foegen et al.'s (2008) study was a first effort to establish the reliability and criterion validity of the measures as static indicators and to explore rough estimates of growth across a school year. Foegen et al. administered six measures (Monitoring Basic Skills Progress-Computation, Monitoring Basic Skills Progress-Concepts and Applications, Basic Facts, Estimation, Missing Number, Complex Quantity Discrimination) at three points in time (fall, winter, spring) to an inclusive general education sample including large numbers of sixth and seventh grade students (N = 242 and 264, respectively), and a smaller number (N = 57) of eighth grade students. They found that these measures generally had acceptable levels of test-retest and alternate-form reliability, with the exception of the Missing Number measure (across grades) and the Monitoring Basic Skills Progress Computation measure (Fuchs, Hamlett, & Fuchs, 1998) in

Grade 7. Although the Basic Facts and Monitoring Basic Skills Progress-Concepts and Applications measures consistently produced reliable scores with a single administration, the other four measures (Monitoring Basic Skills Progress-Computation, Estimation, Missing Number, Complex Quantity Discrimination) proved to be more reliable when the mean of two forms was used in the analyses. The strongest concurrent criterion validity coefficients were obtained for the Monitoring Basic Skills Progress-Concepts and Applications in Grades 6 and 7 and the Complex Quantity Discrimination measure for students in Grade 8 (who did not complete either of the Monitoring Basic Skills Progress measures). Consistently weak relations were obtained with the Monitoring Basic Skills Progress Computation measure for students in Grade 7.

Predictive validity was examined with students in Grades 6 and 7; these results paralleled the concurrent validity results. For students in Grade 6, strong relations were obtained for the Monitoring Basic Skills Progress Concepts and Applications and Computation measures. For students in Grade 7, relations were strongest for the Monitoring Basic Skills Progress Concepts and Applications measures (although the coefficients for three other measures were near $r = .60$: Missing Number, Basic Facts, and Complex Quantity Discrimination).

Purpose of the Study

The purpose of the present study was to replicate the previous research study (Foegen, 2008; Foegen et al., 2008) involving the technical adequacy of six potential measures with brief administration times that make them well-suited for monitoring student progress in mathematics at the middle school level. These brief measures examined included two measures that have been investigated previously with middle school students (facts, estimation; Foegen, 2000, 2008; Foegen & Deno, 2001), two measures that have documented technical adequacy for use at elementary grade levels (Monitoring Basic Skills Progress-Computation, Monitoring Basic Skills Progress-Concepts and Applications; Fuchs, Hamlett, & Fuchs, 1998, 1999), and two measures that represent extensions of elementary numeracy measures developed in other RIPM research (Complex Quantity Discrimination, Missing Number; Foegen et al., 2008). We subsequently refer to these measures as “brief” middle school mathematics measures (suitable for both screening and progress monitoring) to distinguish them from other forms of middle school mathematics assessments, such as the district screening measures described below. This study examined the alternate-form reliability and criterion validity of the brief measures at a single point in time. It differed from the previous study in that it had a larger sample of Grade 8 students and included scores from district-developed screening assessments for students in Grade 7. Another difference was that the Missing Number measure was administered for a longer duration (two minutes, rather than one) to address concerns identified in the earlier study.

Research Questions

The following research questions guided the study:

1. What is the alternate-form reliability of the brief middle school mathematics measures?
2. What is the criterion validity of the measures?
3. Does using the measures in combination increase the variance accounted for in the criterion measures?
4. To what extent do two types of scoring procedures for a brief computation measure produce similar results?
5. Do the brief middle school mathematics measures and the district screening measures produce similar levels of predictive criterion validity?

6. Do the brief middle school mathematics measures and the district screening measures produce similar levels of classification accuracy when predicting whether students will pass the district's high stakes test in mathematics?

Method

Setting and Participants

The study was conducted in a Midwestern middle school. During the 2006-07 school year, the middle school enrolled 472 students (222 in Grade 7 and 250 in Grade 8), with 52 percent being male, 96 percent white, 1 percent African American, 1 percent Asian, 1 percent Hispanic, and less than 1 percent other ethnicities. Thirty-three percent of the students in the district qualified for free or reduced lunch, approximately 15 percent of students were receiving special education services, and 0.3 percent were identified as Limited English Proficient.

Teacher participants in the study included two Grade 7 general education teachers, two Grade 8 general education teachers, and four special education teachers. The Grade 7 teachers taught 5 sections of math each day, while the Grade 8 teachers taught 6 sections. The special education teachers taught from 1 to 4 sections of mathematics each day.

We obtained parental consent and student assent from the 329 students (70%) who participated in the study (134 and 195 students in Grades 7 and 8, respectively). All students in each grade level were assessed to provide the teachers with complete data, but the results reported here are based only on the students for whom consent was obtained. Table 1 displays the demographic characteristics of the student participants. Demographic data were not available for one student in Grade 7 and 5 students in Grade 8. The Total Percentage column in Table 1 was calculated using the 323 students for whom demographic data were available.

Table 1

Demographic Characteristics of Student Participants

	7th Grade (n = 134)	8th Grade (n = 195)	Total Percentage
Gender			
Male	63	91	48%
Female	70	95	51%
Ethnicity			
White	129	184	97%
African American	2	2	1%
Asian	1	3	1%
Hispanic	1	1	< 1%
English Language Learners	0	0	0%
Special Education Services	19	23	13%

Note. Categories may not total 100% due to rounding.

Measures

Brief Middle School Mathematics Measures. Six mathematics measures suitable for screening and progress monitoring were investigated in this study: Monitoring Basic Skills Progress Computation (MBSP-Comp; Fuchs, Hamlett, & Fuchs, 1998), Monitoring Basic Skills Progress-Concepts and Applications (MBSP-ConApp; Fuchs, Hamlett, & Fuchs, 1999), Basic Facts, Estimation, Complex Quantity Discrimination, and Missing Number. The MBSP-Comp task reflected 6th grade curriculum content and required students to compute addition, subtraction, multiplication, and division problems involving whole numbers, fractions, and decimals. The task consisted of 25 problems; students had six minutes to answer as many problems as possible. We scored this measure in two ways. First, we applied the procedures used in our previous research (Foegen et al., 2008) by counting the number of correct digits in each answer and summing across problems to get a total score. We also used a second scoring method that was used by the multi-district education agency within which the school was located. This method also considered correct digits, but all partial answers obtained in solving the problem were included in the count to obtain the total correct digits, as opposed to only considering the digits in the answer. We scored all MBSP-Comp probes using both measures in order to evaluate the relative merits of the two approaches. Figure 1 illustrates the differences between the two methods.

The MBSP-ConApp task reflected Grade 6 concepts and applications curricula and required students to answer problems related to numeration, applied computation, measurement, geometry, percentages, charts and graphs, word problems, ratios and probability, proportions, and variables. Students had seven minutes to complete 24 items. We scored this measure by counting the number of correct responses.

Figure 1. Two Methods for Digits Correct Scoring

Digits Correct – Answer Only	Digits Correct – Full Problem
56 x 35 280 1680 1960	56 x 35 280 (3 digits) 1680 (4 digits) 1960 (4 digits)
In this method, the student's answer would be compared to 1960 to determine the number of correct digits. An answer of 1960 would receive 4 points for 4 correct digits, while an answer of 1860 would be awarded 3 points.	In this method, the digits in each partial product are scored, resulting in a total of 11 points possible for the problem. Students who write the correct answer are awarded all 11 points, even if they did not show the partial products.

The Basic Facts task required students to solve single digit computation combinations (0-9) in each of the four operations. The task consisted of 80 items; students had one minute to respond. We scored the Basic Facts measure by counting the number of correct responses.

The Estimation measure required students to select the most appropriate estimate from three alternatives when presented with a problem involving either computation (i.e., 1.8 x 4 is about) or contextual (story) problems (i.e., Jared had $15.50 from mowing lawns. He made another $9.25 from working at the retirement center. About how much does Jared have now?). The problems included all four operations and whole numbers, fractions, decimals, and percents. The answer alternatives differed by a factor of 10 (i.e., 4, 40, 400) to encourage students to use estimation and number sense or mental math, rather than exact computation, to select the most appropriate estimate. The task consisted of 40 problems and students had 3 minutes to circle the correct alternative for each problem. We scored this measure by counting the number of correct responses and then subtracting from this value one-half the number of incorrect responses. This scoring method provides a correction for the potential that students will guess in responding to the multiple-choice item format and has been found in previous research to produce scores with higher levels of technical adequacy (Foegen, 2000).

The Complex Quantity Discrimination task consisted of 44 pairs of numbers or equations. The task required students analyze the pairs of quantities (i.e., 40 + 7 and 70 + 4) and write the appropriate symbol (greater than [>], less than [<], or equal to [=]) in a box between the quantities. Students had one minute to complete the task. We scored the task by counting the number of correct responses.

To complete the Missing Number task, students were presented with a series of three numbers and one blank indicating a missing fourth element in the sequence (the position of the blank varied). The number patterns included counting sequences, multiples (i.e., 3, 6, 9, ___), skip counting starting on an off digit (i.e., 11, 14, ___, 20) and halving/doubling patterns. Students responded by writing the missing number in the blank. The task consisted of 44 items;

students had two minutes to respond. The duration represents a change from previous studies. We had obtained restricted distributions in earlier studies (Foegen et al., 2008) and wanted to investigate the effects of a longer duration on the technical adequacy of the measure. We scored the measure by counting the number of correct responses. Samples of the researcher-developed mathematics measures, including administration directions, are provided in Appendix A.

Criterion measures. The criterion measures used in the study included teachers' ratings of their students' overall math proficiency, end of course mathematics grades, standardized test scores, and (for Grade 7 students only) scores on three district-developed screening measures. Teachers were asked to rate each student's general proficiency in math relative to other students in his/her class using a Likert scale. The scale ranged from one to seven, with one being least proficient and seven being most proficient. Teachers were asked to try to spread student ratings across the full range of the scale, not clustering students only in the middle or toward one end. All teachers rated students at the same time that students completed the mathematics measures. Prior to any statistical analyses, these scores were standardized for each teacher by converting the scores to *z* scores. A sample of the teacher rating form is provided in Appendix B.

Data on student grades were collected by converting each student's end of year letter grade in mathematics to a number on a 4.0 scale. For example, a grade of A was recorded as 4.0, A- as 3.67, B+ as 3.33, B as 3.0 and so forth. Grades of A+ were awarded to a small number of students and were converted to scores of 4.33.

The district's high stakes achievement test was the Iowa Tests of Basic Skills (ITBS; Hoover, Dunbar, & Frisbie, 2001), which is administered annually for reporting and accountability purposes. The ITBS is a valid and reliable measure that can be used to describe students' developmental level within a content area (Salvia & Ysseldyke, 2007). The test was designed to measure students' critical thinking skills (i.e., interpretation, inferential thinking, classification, analysis, comparisons). The ITBS is designed for students in kindergarten through eighth grade; approximately five and one half hours are required to administer the entire battery of tests. Internal consistency reliability, based on the performance of the standardization sample in 2000, ranged from r = .66 to .93 (Salvia & Ysseldyke, 2007). Salvia and Ysseldyke described three types of evidence the test authors reported in support of the content validity of the ITBS. First, they consulted curriculum guides, textbooks, classroom teachers, and school administrators when writing test items. Second, test items were administered to a national sample of students at each grade level. Third, each test item was reviewed for content fit and item bias by a group of experts (Salvia & Ysseldyke, 2007). The Math Problem Solving and Data Interpretation, Math Concepts and Estimation, and Computation subscales, as well as the Math Total Score were used in the analyses. The Math Concepts and Estimation test includes numeration and number systems, whole numbers, geometry, measurement, fractions, money, and number systems problems. The Math Problem Solving and Data Interpretation test is comprised of two sections. One section requires students to solve short word problems while the other section requires students to interpret information in graph and table format. The Computation subtest requires students to apply all four operations to whole numbers and rational numbers. We recorded the national percentile rank earned by each student on each scale for use in our analyses.

The three district-selected measures included two types of general mathematics measures developed by the teachers and a commercially available algebra prognosis measure (subsequently referred to as District Multiple Choice, District Constructed Response, and Algebra). The District Multiple Choice (District MC) test had 30 items and used a multiple choice response format, while the District Constructed Response (District CR) measure had 25 items and used a constructed response format. For both tests, the content was typical of 7th grade mathematics curriculum in this district, including fractions (simplify, add and subtract, multiply and divide), integers (compare and order), order of operations, whole number operations, and decimal operations. The Algebra test was the Orleans-Hanna Algebra Prognosis Test (Hanna, 1998), a nationally normed instrument for predicting future success in algebra. The district shared scores from these measures; it was participating in a state-wide pilot involving universal screening, and mathematics teachers in the district had used these measures for the pilot. The measures were administered to Grade 7 students only.

Procedures

The ITBS and the Algebra test were group administered to students by district staff using standardized assessment procedures. Standard administration directions (as specified in the teacher directions) and timing requirements were used; the district had administered the ITBS in the early spring and the Algebra measure (to Grade 7 students only) in the fall. Classroom teachers administered the district screening measures (District MC, District CR) at the beginning of the school year.

The first author visited each classroom to explain the study to students and describe the assent/consent process. Student assent forms were completed in class; parent consent letters were sent home with students. Teachers collected the consent forms as the students returned them.

All students present in each class participated in two rounds of data collection in April 2007. General education students in Grade 8 completed two forms each of the MBSP-Comp, Estimation, and Complex Quantity Discrimination measures on Tuesday, April 10. On Thursday, April 12, students completed two forms each of the MBSP-ConApp, Basic Facts, and Missing Number measures. An identical administration procedure was used for Grade 7 general education students on Tuesday, April 24 and Thursday, April 26. Students in special education classes (that included students from both grade levels) completed the measures during one of the two weeks of data collection. Group administration of the tasks took place during normal class periods, with each data collection session lasting between 30 and 40 minutes. No makeup sessions were held for students who were absent on a day when data were collected. For each of the probe types, the administration of the multiple forms was preceded by a brief introduction to the measure and a practice exercise in which students completed several problems similar to those on the measure to ensure they were familiar with the task demands.

Trained data collectors gathered all the data for mathematics progress monitoring. Each data collector participated in a small-group training session lasting approximately 30 minutes. Training was provided by the first author and included a review of administration directions and procedures for each of the six measures.

Project staff completed all of the scoring and data entry for the middle school mathematics progress monitoring measures. For each grade level, 44 probe packets were re-scored to assess inter-scorer agreement; this represented 33% and 23% of the Grade 7 and Grade 8 packets, respectively. We computed an estimate of scoring agreement by counting the number of problems considered agreements (i.e., scored correctly) and the number in which there was a disagreement in scoring (i.e., scoring errors) and dividing the number of agreements by the sum of agreements and disagreements. We computed the scoring accuracy by measure type for each of the selected students and then averaged across all students to obtain an overall estimate of inter-scorer agreement. The scoring accuracy results are presented in Table 2. The data reflect a high rate of mean inter-scorer agreement.

Table 2

Mean and Range for Percentage of Inter-Scorer Agreement

Measure	Mean Agreement	Range
MBSP Computation		
Digits Correct	98.8	79 - 100
Digits Correct-Answer Only	98.7	66 - 100
MBSP Concepts & Applications	98.8	75 - 100
Basic Facts	99.4	78 - 100
Estimation	99.8	86 - 100
Complex Quantity Discrimination	99.3	73 - 100
Missing Number	99.3	63 – 100

Data Analysis

Data analyses involving the brief middle school mathematics measures were conducted using number correct scores for the Basic Facts, MBSP-ConApp, Complex Quantity Discrimination, and Missing Number measures. Digits correct (DC; in the sub-answers and final answer) and digits correct in the answer only (DC-A) scores were used for the MBSP-Comp measure. For the Estimation measure, the final score was computed by subtracting one-half the number of incorrect responses from the total number of correct responses. Any negative scores (resulting when students had more than twice as many incorrect as correct answers) were converted to 0. All of the brief middle school mathematics measures were hand scored using answer keys.

For the criterion measures, teacher ratings were standardized by classroom and the resulting *z*-scores were used in the analyses. For the ITBS, we conducted analyses using national percentile rank scores. Raw scores from the District MC and District CR measures were used in the analyses. For the Algebra measure, scores from the Orleans-Hanna Algebra Prognosis Test were reported as percentile ranks. We computed Pearson product moment correlation coefficients in our analyses of reliability and criterion validity. Regression analyses were used to evaluate the benefits of using the measures in combination and discriminant analyses were used to examine classification accuracy in predicting passing scores on the high stakes achievement test.

Results

This section begins with descriptive statistics for all study measures. We next move to analyses specific to each of the research questions. Means and standard deviations, along with kurtosis and skewness statistics, for each of the brief middle school mathematics measures by grade level are presented in Table 3. Tests of skewness and kurtosis were conducted for all study variables and distributions met the assumptions for use of Pearson product moment correlations in our subsequent analyses of reliability and validity.

In reviewing the data in Table 3, we considered the nature of the distributions produced on each of the brief middle school mathematics measures. We were particularly interested in any floor or ceiling effects and the size of the standard deviations. Although scores of zero were observed for the MBSP-ConAPP, Basic Facts, Estimation, and Missing Number tasks, in all but one instance, only a single student had obtained a score of zero. The one exception was Form B of the MBSP-ConApp, on which two students obtained scores of zero.

We examined the standard deviations produced for each measure and found that the MBSP-Comp (digits correct) produced a much wider distribution of scores, with standard deviations at least double the magnitude of those for the other measures. Among the remaining

Table 3

Descriptive Statistics for the Brief Middle School Mathematics Measures

Grade 7								
Measure	Form	*n*	Min	Max	*M*	*SD*	Skew	Kurt
MBSP-Comp	Form A	129	17	139	72.5	23.8	.45	.02
(DC)	Form B	128	16	171	77.6	27.7	.46	.18
	Mean of 2	129	16.5	135	75.0	23.6	.43	.03
MBSP-Comp	Form A	129	17	69	39.1	9.5	.52	.43
(DCA)	Form B	128	12	65	36.3	10.2	.23	-.36
	Mean of 2	129	16.5	63	37.7	8.8	.36	-.12
MBSP-ConApp	Form A	131	0	25	13.15	5.4	.06	-.52
	Form B	131	2	26	11.44	5.0	.09	-.36
	Mean of 2	131	2	24	12.53	5.0	.04	-.55
Basic Facts	Form A	130	8	53	30.01	9.3	.06	-.23
	Form B	130	0	52	30.03	9.9	-.09	-.31
	Mean of 2	130	9	53	30.29	9.1	.07	-.45
Estimation	Form A	128	0.5	30.5	11.83	5.7	.30	-.11
	Form B	128	0.5	27.5	12.03	5.5	-.02	-.41
	Mean of 2	128	2.5	29.0	11.93	5.3	.21	-.25
Complex Quantity	Form A	128	3	29	16.26	5.8	-.06	-.66
Discrimination	Form B	128	3	31	18.26	6.3	-.09	-.43
	Mean of 2	128	4	19.5	17.26	5.8	-.11	-.37
Missing Number	Form A	130	0	31	15.69	5.9	.20	.28
	Form B	130	1	33	16.48	6.1	.04	.03
	Mean of 2	130	2	31	16.32	5.8	.08	.11

Table 3 (continued)

Descriptive Statistics for the Brief Middle School Mathematics Measures

Grade 8								
Measure	Form	*n*	Min	Max	*M*	*SD*	Skew	Kurt
MBSP-Comp	Form A	189	7	182	88.06	24.5	.23	-.35
(DC)	Form B	189	15	200	95.23	41.2	.33	-.65
	Mean of 2	189	11	191	91.65	36.2	.28	-.57
MBSP-Comp	Form A	189	7	74	44.71	12.1	.08	-.09
(DCA)	Form B	189	14	79	42.34	13.1	.13	-.56
	Mean of 2	189	10.5	75	43.52	11.6	.09	-.20
MBSP-ConApp	Form A	184	1	32	15.79	6.6	.10	-.39
	Form B	185	0	30	13.56	6.2	.24	-.36
	Mean of 2	185	0	30	14.86	6.2	.09	-.41
Basic Facts	Form A	185	8	80	33.00	12.2	.53	.55
	Form B	185	5	73	32.06	12.3	.58	.16
	Mean of 2	185	8	76	32.80	11.9	.57	.46
Estimation	Form A	189	1	38.5	12.55	6.2	.75	1.4
	Form B	189	0	40	12.70	6.6	.72	1.1
	Mean of 2	189	1.5	39.25	12.63	6.1	.80	1.5
Complex Quantity	Form A	187	1	34	17.03	6.5	.10	-.40
Discrimination	Form B	188	1	34	19.97	6.5	-.28	-.46
	Mean of 2	188	1	31.5	18.52	6.0	-.19	-.30
Missing Number	Form A	185	2	44	17.23	7.3	.96	1.5
	Form B	185	4	43	18.28	7.3	.89	1.2
	Mean of 2	185	5	44	18.00	7.1	1.0	1.6

Note. Skew = skewness; Kurt = kurtosis.

measures, the standard deviations were greatest for the MBSP-Comp (digits correct in the answer) and the Basic Facts measures. In general, the standard deviations for students in Grade 8 were larger than those obtained for students in Grade 7. Skewness and kurtosis estimates were examined for all measures and generally fell within the expected parameters for normality. Two exceptions were the Grade 8 distributions for Estimation and Missing Number, which demonstrated positive kurtosis values exceeding 1, suggesting that the distributions were more "peaked," with larger numbers of values in the middle of the distribution. An examination of the mean scores revealed increases from Grade 7 to Grade 8 in the expected direction.

Descriptive statistics for the criterion measures are presented in Table 4. ITBS scores are reported in percentile ranks and teacher ratings as *z* scores, standardized by teacher. For Grade 7 students, district screening measures are reported as raw scores for District MC and District CR, and as percentile ranks for Algebra. Means on the ITBS reveal mean student performance levels slightly above national norms. Scores on the two district screeners for general math (District MC and District CR) approached or exceeded accepted levels for skewness, with many students scoring in the upper range of the distribution.

Table 4

Descriptive Statistics for Criterion Variables

	Measure	*n*	Min	Max	*M*	*SD*	Skew	Kurt
Grade 7								
ITBS	Problem Solving & Data Interpretation	133	3	99	59.21	26.3	-.53	-.74
	Concepts & Estimation	133	1	99	56.98	26.1	-.33	-.95
	Computation	133	2	96	55.56	24.1	-.46	-.82
	Total Math	133	1	99	58.11	25.9	-.43	-.78
Teacher	Rating	134	-2.24	1.67	-.008	1.03	-.11	-.77
District	District MC	134	6	29	22.5	5.3	-.97	.37
Screeners	District CR	134	5	25	19.28	3.8	-1.1	1.3
	Algebra	134	0	99	57.47	31.34	-.60	-.79
Grade 8								
	Measure	*n*	Min	Max	*M*	*SD*	Skew	Kurt
ITBS	Problem Solving & Data Interpretation	190	1	99	59.08	25.9	-.28	-.89
	Concepts & Estimation	190	1	99	59.05	26.3	-.32	-.93
	Computation	190	2	99	56.26	28.4	-.28	-1.1
	Total Math	190	4	99	59.42	26.0	-.32	-.83
Teacher	Rating	194	-1.84	1.64	-.0002	--	-.21	-.95

Note. Skew = skewness; Kurt = kurtosis.

Intercorrelations between the brief middle school mathematics measures are presented in Table 5. Moderate to strong positive relations were observed between all measures in both grade levels. Readers are reminded that the first two columns reflect two approaches to scoring the MBSP-Comp (digits correct and digits correct in the answer only). The relations between the measures were generally stronger in Grade 8 than in Grade 7.

Table 5

Intercorrelation Matrix for the Brief Middle School Math Measures

	1.	2.	3.	4.	5.	6.
Grade 7						
1. MBSP-Comp (DC)	--					
2. MBSP-Comp (DCA)	.88	--				
3. MBSP-ConApp	.61	.53	--			
4. Basic Facts	.61	.45	.61	--		
5. Estimation	.47	.45	.53	.54	--	
6. Complex Quantity Discrimination	.46	.43	.56	.51	.55	--
7. Missing Number	.54	.47	.72	.61	.61	.59
Grade 8						
1. MBSP-Comp (DC)	--					
2. MBSP-Comp (DCA)	.92	--				
3. MBSP-ConApp	.66	.58	--			
4. Basic Facts	.66	.62	.55	--		
5. Estimation	.53	.48	.68	.55	--	
6. Complex Quantity Discrimination	.59	.56	.62	.65	.55	--
7. Missing Number	.64	.56	.69	.70	.72	.65

Note. All coefficients significant at $p < .01$.

Intercorrelations between the criterion variables are presented in Table 6. We observed moderate to strong positive relations between most of the criterion measures.

Table 6

Intercorrelations Between the Criterion Measures

	Measure	1	2	3	4	5	6	7
Grade 7								
1	ITBS Problem Solving and Data Interpretation	--						
2	ITBS Concepts & Estimation	.82	--					
3	ITBS Computation	.47	.53	--				
4	ITBS Total Math	.97	.94	.52	--			
5	Teacher Rating	.61	.63	.47	.65	--		
6	District MC	.72	.80	.52	.79	.62	--	
7	District CR	.68	.73	.48	.73	.54	.79	--
8	District Algebra	.73	.79	.52	.79	.70	.78	.74
			Grade 8					
1	ITBS Problem Solving and Data Interpretation	--						
2	ITBS Concepts & Estimation	.96	--					
3	ITBS Computation	.65	.68	--				
4	ITBS Total Math	.94	.94	.66	--			
5	Teacher Rating	.63	.66	.59	.67			

Note: All correlations significant, $p < .01$

Research Question 1: What is the reliability of the brief middle school mathematic measures?

Alternate-form reliability. We examined alternate-form reliability by computing Pearson product moment correlation coefficients between the scores students obtained on the two forms of each of the six brief middle school mathematics measures. For the MBSP-Comp, we examined alternate-form reliability for both types of scoring. Table 7 displays the results of the alternate-form reliability analyses. For most of the measures, the conventional benchmark of $r \geq .80$ was met across grade levels. The exceptions to this pattern were the MBSP-Comp measure, which fell well below this benchmark in Grade 7 for both scoring methods and slightly below the benchmark for the DCA (digits correct in the answer) method in Grade 8. For Grade 8 students, the Complex Quantity Discrimination measure also fell slightly below the desired level. In general, reliability coefficients were higher for Grade 8 than for Grade 7.

Table 7

Alternate-Form Reliability of the Brief Middle School Mathematics Measures

	Grade 7		Grade 8	
	N	*r*	*N*	*r*
MBSP Comp				
Digits correct (DC)	128	.69	189	.82
Digits correct in answer (DCA)	128	.58	189	.71
MBSP ConApp	131	.84	184	.86
Basic Facts	130	.81	185	.88
Estimation	125	.81	189	.83
CQD	128	.83	187	.72
Missing Number	130	.83	185	.91

Note: All correlations significant, $p < .01$

Research Question 2: What is the criterion validity of the brief middle school mathematics measures?

The results of the criterion validity analyses are reported in Table 8. Criterion validity coefficients were calculated using the mean of two probes. The criterion measures used in the

Table 8 *Criterion Validity Coefficients for the Middle School Mathematics Measures*

	Comp-DC	Comp-DCA	ConApp	Basic Facts	Estimation	Complex Quant. Dis.	Missing Number
Grade 7							
ITBS							
Data & Probability	.43	.38	.74	.48	.64	.53	.61
Concepts & Estimation	.43	.34	.75	.48	.59	.48	.65
Computation	.48	.41	.41	.49	.40	.38	.49
Math Total	.45	.38	.78	.50	.65	.54	.66
District Screeners							
District MC	.38	.33	.69	.46	.56	.52	.55
District CR	.41	.33	.64	.50	.56	.59	.62
Algebra	.41	.34	.69	.56	.59	.57	.65
Teacher Rating	.45	.36	.73	.54	.47	.46	.50
Grade 8							
ITBS							
Data & Probability	.64	.54	.82	.55	.69	.64	.69
Concepts & Estimation	.66	.56	.83	.57	.66	.64	.70
Computation	.68	.60	.63	.61	.51	.53	.59
Math Total	.62	.52	.83	.54	.71	.65	.72
Teacher Rating	.60	.51	.67	.48	.52	.50	.55

Note. All coefficients significant at $p < .01$. Comp-DC = MBSP-Comp, digits correct; Comp-DCA=MBSP Comp, digits correct in answer; ConApp = MBSP ConApp; Complex Quant. Dis. = Complex Quantity Discrimination; CR = Constructed Response; MC = Multiple Choice.

study included teacher ratings of students' overall math proficiency, standardized test scores (ITBS), and, for Grade 7 students only, three district screening measures.

Three sets of patterns emerged from the findings reported in Table 8. The first set involved the strongest overall predictors among the brief middle school mathematics measures, while the second set involved the ITBS Computation subtest. The third set of patterns involved the Teacher Ratings. We address each of these in turn.

We first considered the correlations between the criterion measures and each of the brief measures (e.g., reviewing Table 8 on a row-by-row basis). The brief middle school mathematics measure that demonstrated the strongest relations with the criterion measures was the MBSP ConApp. Across both grade levels and three of the four ITBS subtests (all but Computation), this measure produced the highest correlation coefficients in comparison to the other brief measures. After the MBSP ConApp, the Estimation and Missing Number measures consistently produced the next highest levels of correlation with the criterion measures. The Basic Facts, Complex Quantity Discrimination, and MBSP-Comp DC and DCA were consistently among the measures producing the lowest correlation coefficients (with some exceptions).

The second pattern involved the ITBS Computation subtest. Among Grade 7 students, scores on the ITBS Computation subtest were the most highly correlated with the Missing Number, MBSP-Comp DC, and Basic Facts measures. In Grade 8, ITBS Computation scores were mostly strongly related to students' scores on the MBSP-Comp DC, MBSP-ConApp, and Basic Facts measures. Correlation coefficients were higher across these relations for Grade 8 students than for Grade 7 students. The strong relations between the Computation subtest and the MBSP-Comp and Basic Facts measures were not surprising, given the common emphasis on computational proficiency. We were somewhat surprised to find that Grade 8 students' scores on the MBSP ConApp correlated so highly with the Computation subtest, given the more limited emphasis on computation in the Concepts and Applications measure.

Finally, correlation results for the Teacher Ratings for both grade levels reflected the importance of both broader conceptual understandings and computational proficiency. At both grade levels, the highest correlation coefficient for Teacher Ratings was the MBSP-ConApp, the measure with the broadest range of mathematical skills and concepts. The second highest coefficient was with a measure reflecting computation skills (Basic Facts in Grade 7 and MBSP-Comp, DC in Grade 8). For both grade levels, the next strongest relation was with the Missing Number measure.

Research Question 3: Does using the measures in combination increase the variance accounted for in the criterion measures?

To further explore the degree to which the measures overlap in their predictive power, we conducted two multiple regression analyses for each grade. In both, we used the brief middle school mathematics measures to predict an outcome variable; the outcome was the ITBS Total Math score for the first analysis and Teacher Ratings for the second. The results of these analyses are presented in Tables 9 and 10.

The regression analyses further reinforce the predictive power of the MBSP-ConApp measure for both the ITBS Total Math scores and the Teacher Ratings. When predicting the ITBS Total Math (the high stakes outcome measure for the district) for Grade 7 students, a model that included the MBSP-ConApp and the Estimation task accounted for 63% of the variance in Total Math scores. For Grade 8 students, a model that included these two measures, along with the Missing Number task accounted for 74% of the variance in Total Math scores.

Table 9

Regression Results for Using Brief Middle School Mathematics Measures to Predict ITBS Total Mathematics Scores

Variable	*B*	*SE B*	ß
Grade 7 (*N* = 123)			
MBSP-ConApp	3.36	.398	.642**
Estimation	1.00	.372	.204**
Grade 8 (*N* = 174)			
MBSP-ConApp	2.39	.250	.565**
Estimation	0.81	.256	.192**
Missing Number	0.67	.229	.185**

Note. R^2 = .63 for Grade 7, R^2 = .74 for Grade 8. ** = $p < .01$

Table 10

Regression Results for Using Brief Middle School Mathematics Measures to Predict Teacher Ratings

Variable	*B*	*SE B*	ß
Grade 7 (*N* = 124)			
MBSP-ConApp	.153	.012	.748**
Grade 8 (*N* = 177)			
MBSP-ConApp	.079	.012	.491**
MBSP-Comp DC	.007	.002	.269**

Note. R^2 = .56 for Grade 7, R^2 = .49 for Grade 8. ** = $p < .01$

Teacher Ratings were not predicted with similar levels of success, as evidenced by the lower R^2 values. In Grade 7, a single factor model using only the MBSP-ConApp accounted for 56% of the variability in Teacher Ratings; none of the other measures accounted for additional unique variance. In Grade 8, a model using both of the MBSP measures (Comp-DC and ConApp) accounted for just under half (49%) of the variance. The results of the regression analyses suggest that there is considerable overlap in the variance accounted for by the brief middle school mathematics measures.

Research Question 4: To what extent do two types of scoring procedures for a brief computation measure produce similar results?

This question arose out of conversations with special education staff at the school regarding the procedures to be used to score the MBSP-Comp. The teachers had been instructed by area education agency staff to count the number of correct digits in all sub-steps of each problem, in addition to the correct digits in the answer, to get a total "digits correct" score for each problem. In previous research (Foegen et al., 2008), the first author had also used counts of digits correct, but only counted the correct digits in each answer, without including the sub-steps of each problem. Given this discrepancy, a secondary purpose of the study was to gather data on a direct comparison of the two methods. We scored each student's MBSP-Comp probes using both the "digits correct" (DC) procedure used in the school, and with the "digits correct in the answer" (DCA) procedure used previously by the authors.

The results of the study revealed strong relations between the scores produced using the two methods (.88 and .92 in Grades 7 and 8, respectively; see Table 5). Alternate-form reliability coefficients were higher for the DC method for both grade levels (.11 points in each case, see Table 7). The same pattern was observed in the criterion validity coefficients, with the DC method consistently producing higher coefficients (with increases ranging from .05 to .10, see Table 8).

Research Question 5: How do the technical features of the brief middle school mathematics measures compare to those of the district screening measures?

To provide a more direct comparison of the brief middle school mathematics measures that served as the primary focus of this study with the district screening measures, we conducted a series of analyses using the Grade 7 data that employed correlation, regression, and discriminant analysis techniques. First, we compared the strength of the correlations between the measures and two outcome variables (ITBS scores and Teacher Ratings). These results are reported in Table 11.

The data in Table 11 permit a direct comparison of the correlations produced by the brief middle school mathematics measures and the district screening measures. The results indicate that the district screeners generally produced correlation coefficients that were as high or higher than those produced by the middle school mathematics measures. Of the three screeners, the Algebra assessment generally produced the highest coefficients, followed closely by the District MC screener (multiple choice). The District CR screener (constructed response) produced the lowest coefficients of the three screening tools, but was generally similar (with the exception of teacher ratings) to the best of the brief middle school mathematics measures, the MBSP-ConApp. All of the remaining brief middle school mathematics measures produced coefficients lower than those produced by the district screeners.

Table 11

Criterion Validity Coefficients for the Brief Middle School Mathematics Measures and District Screeners

	ITBS PrData	ITBS ConEst	ITBS Comp	ITBS Total Math	Teacher Rating
Middle School Math Measures					
MBSP Comp					
Digits correct	.43	.43	.48	.45	.45
Digits correct in answer	.38	.34	.41	.38	.36
MBSP ConApp	.74	.75	.41	.78	.73
Basic Facts	.48	.48	.49	.50	.51
Estimation	.64	.59	.40	.65	.47
CQD	.53	.48	.38	.54	.46
Missing Number	.61	.65	.49	.66	.50
District Screeners					
District MC	.72	.80	.52	.79	.62
District CR	.68	.73	.48	.73	.54
Algebra	.73	.79	.52	.79	.70

Note. All coefficients significant at $p < .01$. ITBS = Iowa Tests of Basic Skills, PrData = Problem Solving and Data Interpretation subtest, ConEst = Concepts and Estimation subtest, Comp = Computation subtest.

The second set of analyses used regression to determine which combinations of middle school mathematics measures and district screeners would best predict ITBS Total Math and Teacher Ratings. These results are reported in Table 12.

Table 12

Regression Results for Using Middle School Mathematics Measures and District Screeners to Predict ITBS Total Math and Teacher Ratings

Variable	*B*	*SE B*	ß	R^2
ITBS Total Math (*N* = 123)				
Algebra	0.26	.064	.313**	.642
MBSP ConApp	1.83	.339	.350**	.735
District MC	1.49	.369	.307**	.765
Teacher Ratings (*N* = 124)				
MBSP-ConApp	0.13	.018	.609**	.560
Algebra	0.01	.003	.399**	.621
Missing Number	-0.03	.015	-.191*	.636

Note. ** $p < .01$; * $p < .05$.

When the predictor variable was the ITBS Total Math score, three measures contributed to the prediction equation at a statistically significant level: Algebra, MBSP-ConApp, and District MC. Together, students' scores on these three measures accounted for 77% of the variance in ITBS Total Math scores. When the predictor variable was Teacher Ratings, three measures again contributed to the equation: MBSP-ConApp, Algebra, and Missing Number. Together, scores on these three measures accounted for 64% of the variance in Teacher Ratings. Substantial increases in the total percentage of variance accounted for resulted when a second measure was included with the first, but the subsequent gains produced by adding a third measure, while statistically significant, were relatively minimal.

Research Question 6: Do the brief middle school mathematics measures and the district screening measures produce similar levels of classification accuracy when predicting whether students will pass the district's high stakes test in mathematics?

Next, we computed two discriminant analyses to compare the predictive accuracy of the Algebra and MBSP-ConApp, the two measures that were included in both sets of regression results and produced the strongest individual correlation coefficients with the criterion measures. To conduct these analyses, we coded students' ITBS Total Math scores into binary categories. Passing, coded 1, was defined as an ITBS Total Math percentile rank of 41 or more. Failing, coded 0, was defined as an ITBS Total Math percentile rank of 40 or below. Only Grade 7 students (N = 130) with data for all relevant variables were included in these analyses. We first ran separate discriminant analyses using the District Algebra and MBSP-ConApp as individual predictors. The discriminant analysis results are presented a classification table in the first two sections of Table 13.

The results presented in Table 13 reflect identical levels of classification accuracy for the MBSP-ConApp and the Algebra measure. The MBSP ConApp resulted in two less false positives (students who are predicted to fail, but actually passed the ITBS Total Math) in comparison to the Algebra measure, while the Algebra measure produced two less false negatives (students predicted to pass, but who failed the ITBS) than the MBSP ConApp.

The third section of Table 13 shows the results obtained when the prediction was based on the sum of students' scores on the MBSP ConApp and the District Algebra measure. This analysis revealed a very similar (88.5% vs. 87.7%) rate of classification accuracy for predicting passing on the district's high stakes mathematics assessment. Little additional benefit was gained by combining students' scores on the measures.

Table 13

Classification Accuracy for MBSP ConApp and District Algebra when Predicting a Passing Score on ITBS Total Math

Predictor Variable = MBSP ConApp (*N* = 130)		
	Predicted to Fail	Predicted to Pass
Actually Failed	*n* = 19	*n* = 12
Actually Passed	*n* = 4	*n* = 95

Predictor Variable = District Algebra (*N* = 130)		
	Predicted to Fail	Predicted to Pass
Actually Failed	*n* = 21	*n* = 10
Actually Passed	*n* = 6	*n* = 93

Predictor Variable = District Algebra + MBSP ConApp (*N* = 130)		
	Predicted to Fail	Predicted to Pass
Actually Failed	*n* = 22	*n* = 9
Actually Passed	*n* = 6	*n* = 93

Note. Classification accuracy = 87.7% for MBSP-ConApp, 87.7% for District Algebra, 88.5% for District Algebra + MBSP ConApp.

Discussion and Future Research

The purpose of this study was to replicate previous research (Foegen et al., 2008) on the technical adequacy of six brief middle school mathematics measures for use as potential screening measures. In addition, the study also compared the criterion validity and predictive accuracy of these six measures to three screening tools used by the district as part of a statewide pilot project in which the seventh grade teachers were participating.

Alternate-form reliability coefficients in the present study were comparable to those obtained in the earlier research, with the exception of the Missing Number and Complex Quantity Discrimination measures. As in the earlier research, the MBSP-Comp was less reliable than most of the other measures and, at Grade 7, was well below the conventional benchmark of $r = .80$ for reliability coefficients. The remaining measures were above or approached this level. In Grade 8, the CQD measure was somewhat lower ($r = .72$) than coefficients resulting for the same measure in the earlier study (which ranged from .77 to .89 across three administrations over the course of a school year). In contrast, the Missing Number task, which had relatively low levels of alternate-form reliability in the earlier study, met or exceeded conventional benchmarks in the present study. This result is likely due to the extended administration duration (2 minutes, rather than 1) in the present study.

In the present study, criterion validity coefficients were stronger across the range of measures than those obtained in the previous study. Whereas previous concurrent validity coefficients ranged from .30 to .60, the coefficients in the present study were generally in the .40 to .80 range. As in previous research, the MBSP-ConApp was the strongest of the six middle school mathematics measures. Notably, the district-identified screening measures demonstrated criterion validity coefficients that met or exceeded those of the brief middle school mathematics measures administered by the research team. The district measures differed from the brief measures in that they were more comprehensive (representing the range of mathematics concepts for Grade 7) and they required a longer administration time (a full class period). It is interesting that in comparing the District MC to the District CR measures, the MC (multiple choice) measure produced higher criterion validity coefficients with the district's high stakes mathematics assessment (ITBS) across all subtests.

The present study extends previous research by exploring the use of measures in combination to predict important outcomes. The regression results revealed that when the outcome variable was the Mathematics subtest of the Iowa Tests of Basic Skills (the high stakes measure used for accountability in this district), a combination of three measures could account for 77% of the variance. Not surprisingly, prediction of Teacher Ratings was somewhat less accurate.

The discriminant analyses provide an indication of the viability of the measures for screening purposes. While the overall classification rates were adequate (87.7%), educators must note that the number of false negatives (students predicted to pass the high stakes test, but who failed) exceed the number of false positives (students who were predicted to fail, but passed). This pattern occurred for the District Algebra measure, the MBSP ConApp, and the combination of the two.

As educators seek measures to support universal screening and subsequent progress monitoring tools, they will need to balance the qualities of technical adequacy with more pragmatic concerns related to efficiency. The district-developed multiple choice measure and the district algebra measure examined in this study produced stronger criterion validity coefficients with the high stakes achievement measure than most of the brief measures. However, these measures required a full class period for administration purposes and are available only in a single form, making them impractical for progress monitoring purposes. Educators may determine that the added level of predictive ability with a longer, more comprehensive measure merits investing more time for administration for a single universal screening at the beginning of the year. In contrast, the MBSP ConApp, which was the strongest brief measure, might be used to monitor student progress or to screen students who were close to the cut off level at subsequent points in the school year. This measure, which requires less than 10 minutes of administration time, would likely provide beneficial data on student performance without requiring the more substantial commitment of student and teacher time for administration.

Future research should extend research on classification accuracy, exploring the use of more advanced statistical techniques to set cut scores for screening purposes. The results of this study suggest that measures that are more comprehensive in representing mathematical content are likely to be better suited for screening purposes. Likewise, future research should explore the technical adequacy of frequent administration of the brief measures for purposes of progress monitoring and determining the effects of intervention programs.

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Appendix A

Researcher-developed math measures

Estimation

Complex Quantity Discrimination

Basic Facts

Missing Number

Administration Directions

Day 1

Day 2

Estimation Probe 1

A large pizza has 16 slices. 5 kids will share the pizza. About how many slices will each kid get? 0.3 3 30	22 x 59 is about 12 120 1,200	It takes 2 1/2 yards of fabric to make a costume for the play. Mom has 11 yards of fabric. About how many costumes can she make? 0.4 4 40	$8\overline{)555}$ is about 0.7 7 70	The gym shoes cost $82. They are on sale for 25% off. About how much will you save? $20 $200 $2,000
4 x 9.3 is about 0.36 3.6 36	Edward makes $4 per hour doing odd jobs. If he works 11 hours, about how much will he earn? $4 $40 $400	0.45 - 0.14 is about 0.3 3 30	Luis wants to buy 6 new books. If each one costs $12, about how much will Luis pay for the 6? $0.60 $6 $60	$8\overline{)0.19}$ is about 0.02 0.2 2
Christine's car went 300 miles on 11 gallons of gas. About how many miles per gallon did the car go? 27 270 2,700	97.7 - 21.4 is about 0.8 8 80	There are 30 students in the class. Each student paid $3.50 for the bus. About how much money do they have for a bus? $10 $100 $1,000	73 - 18 is about 5 50 500	Joel earns $4.25 per hour stacking shelves at the grocery store. About how much will he earn in 20 hours? $0.80 $8 $80
78 + 17 is about 10 100 1,000	The car's gas tank holds 14 gallons. You just pumped in 11.75 gallons to make the tank full. About how many gallons were already in the tank? 2 20 200	219 + 876 is about 10 100 1,000	For her birthday, Sue received $19 from Grandpa and $32 from Aunt Sue. About how much did she receive from these two people? $5 $50 $500	$82\overline{)71.3}$ about 1 10 100

Complex Quantity Discrimination Form A

50 + 9 ☐ 9 + 50	18 ☐ 2 • 9	67 ☐ 76	.3 ☐ .03
56 ☐ 7 • 8	.5 ☐ .2	50 • 7 ☐ 5 • 70	15 ☐ 15 ÷ 3
32 ÷ 8 ☐ 32 ÷ 5	60 + 2 ☐ 20 + 6	60 • 4 ☐ 6 • 40	10 ☐ 10 – 7
70 + 3 ☐ 72 + 3	20 – 8 ☐ 20 – 9	85 ☐ 80	79 ☐ 70 + 9
53 ☐ 35	.4 ☐ .3	10 – 2 ☐ 13 – 2	$\frac{1}{6}$ ☐ $\frac{1}{2}$
70 – 1 ☐ 71 – 1	50 ☐ 50 + 1	29 ☐ 20	26 ☐ 2 + 6
$\frac{1}{5}$ ☐ $\frac{1}{9}$	90 ☐ 91 – 1	90 ☐ 90 + 2	20 ☐ 20 – 8
9 ☐ 90	48 ÷ 6 ☐ 48 ÷ 9	70 • 80 ☐ 70 • 8	80 + 4 ☐ 40 + 8
3 • 20 ☐ 3 • 2	15 ☐ 15 ÷ 5	74 ☐ 7 + 4	65 ☐ 60 + 5
1 • 90 ☐ 1 • 9	.9 ☐ .09	30 ☐ 34 – 4	80 – 9 ☐ 80 – 4
3 ☐ 30	40 • 50 ☐ 40 • 5	10 + 9 ☐ 9 + 10	60 + 4 ☐ 61 + 4

Project RIPM, Iowa State University

Facts Probe 1

1 - 1 =	8 x 1 =	5 x 5 =	1 x 7 =
4 x 7 =	5 x 7 =	4 + 6 =	9 x 5 =
3 + 0 =	$3\overline{)12}$ =	$2\overline{)14}$ =	$6\overline{)6}$ =
12 - 9 =	7 + 4 =	0 x 7 =	7 - 4 =
$5\overline{)10}$ =	$8\overline{)48}$ =	11 - 7 =	$4\overline{)12}$ =
8 - 2 =	9 + 6 =	6 + 6 =	1 x 2 =
8 + 7 =	0 x 0 =	11 - 2 =	8 - 5 =
6 - 2 =	7 + 0 =	3 + 3 =	17 - 9 =
10 - 4 =	9 x 9 =	$4\overline{)4}$ =	$1\overline{)5}$ =
$1\overline{)1}$ =	2 -2 =	5 + 9 =	7 x 8 =
$6\overline{)54}$ =	9 - 3 =	$4\overline{)32}$ =	16 - 7 =
4 + 5 =	14 - 9 =	7 + 6 =	2 x 6 =
8 + 8 =	13 - 6 =	2 x 4 =	$5\overline{)0}$ =
1 + 0 =	6 x 2 =	2 + 8 =	1 + 8 =
$9\overline{)63}$ =	$3\overline{)27}$ =	$3\overline{)15}$ =	$9\overline{)36}$ =
0 + 0 =	8 x 3 =	8 + 5 =	$7\overline{)42}$ =
13 - 8 =	$6\overline{)24}$ =	2 x 2 =	2 - 0 =
9 + 1 =	6 - 3 =	0 + 7 =	3 x 5 =
$8\overline{)8}$ =	4 x 9 =	9 - 7 =	$5\overline{)40}$ =
5 + 2 =	7 - 0 =	1 x 6 =	8 + 0 =

Missing Number Form A

37, 40, 43, ___	11, 22, 44, ___	43, ___, 45, 46	12, ___, 24, 30
30, 35, 40, ___	32, 28, ___, 20	21, 16, 11, ___	50, 60, ___, 80
48, 40, 32, ___	25, 20, 15, ___	24, ___, 12, 6	35, ___, 37, 38
18, 16, 14, ___	19, 20, 21, ___	6, ___, 12, 15	8, 16, 32, ___
80, 79, ___, 77	56, 57, ___, 59	88, 44, 22, ___	27, ___, 21, 18
24, 12, 6, ___	36, ___, 54, 63	14, 16, 18, ___	56, 49, ___, 35
70, 60, ___, 40	14, 21, ___, 35	49, 45, 41, ___	28, 25, 22, ___
10, 9, 8, ___	43, 45, 47, ___	47, 57, 67, ___	38, 42, 46, ___
2, 4, 8, ___	28, ___, 26, 25	7, 12, 17, ___	80, 40, 20, ___
40, 48, 56, ___	12, 16, ___, 24	81, ___, 63, 54	48, 38, 28, ___
17, 15, 13, ___	56, 28, 14, ___	13, 26, 52, ___	65, 64, ___, 62

Project RIPM, Iowa State University

Research Institute Progress Monitoring (RIPM)
2006-2007
Middle School Measures Study

General Introduction to Progress Monitoring
Standard Directions – Day 1

"Good morning/afternoon! My name is ______________ and I'm part of the math progress monitoring research team at Iowa State University. As you know, your class and other math classes here at XXX Middle School are working with ISU on a project to learn more about how brief assessments can be used to help teachers do an even better job of helping students learn mathematics. Today you will complete the first set of worksheets for the project. Remember that all students will be completing the worksheets, but your scores will only be used for the research project if both you and your parent/guardian have given permission.

There are a few things you should know about these worksheets before we begin. First, you will be given a limited amount of time to work on the problems. These worksheets are different from classroom tests or quizzes and are not meant to be completely finished. Don't be worried if you do not complete a large number of problems. What's important is that as you learn more about math in this class, your scores will improve.

Second, keep in mind that the object of the activity is to correctly answer as many questions as you can in the amount of time given. There may be problems on the worksheets that are difficult or unfamiliar. Please look at each problem. If you do not know how to answer it, skip it, and go on to the next problem. DO NOT spend a great deal of time on any one problem. If you get to the end of the sheet and still have time to work, go back to the problems you skipped and try to solve them.

Third, we will use your scores on these worksheets to decide which types of activities are most helpful to teachers in understanding your math knowledge. Because of this, it's important that you try your best on each of the sheets.

Do you have any questions at this point?" [Pause and respond to any student questions. HAND OUT STUDENT BOOKLETS.]

This booklet contains the worksheets you will be doing today. Please fill in the information on the front cover and print so that we will be able to read what you write. [Pause and allow students to finish. Monitor to see that they are including the needed information, but not writing anything in the 'For Researcher Use' section at the bottom.

To help you learn about each new type of activity, we will start with a sample page. This page will have sample questions similar to the questions on the worksheet. We will also do a short exercise in which you can practice answering these types of questions. Think of the sample pages as 'warm-up' activities to get you ready to do your best on the worksheets. At the end of each activity, you will see a red page with a stop sign on it. This tells you that you have come to the end of this activity and should not turn any farther in the book. The STOP pages look like this [hold up example]. ***Please open your booklet to the first page.***

MBSP Computation
Standard Directions

Set timer to 5 minutes.

“***The first type of worksheet you will be doing is a Computation worksheet.*** [Hold up booklet with Computation sample page showing.] ***This sample page shows some examples of the types of problems on this worksheet. You can see that problem A has been answered. In this problem, two sevenths multiplied by five eighths is five 28ths. Notice that the answer has been written in lowest terms. You may call this reducing, or simplifying, the fraction. You are encouraged to show your work as you solve these problems. Now try problem B. When you do division problems on this worksheet, please write the remainder as a decimal and round to two places. Please take a minute to solve problem B.*** [Pause as students work.] ***What is the answer to problem B?*** [Wait for students to volunteer 1.04, or one and four hundredths]. ***Yes, that’s correct.***

Here’s how you do this worksheet. Start here (point to the upper left corner) ***and move across each row from left to right*** (demonstrate). ***When you come to a problem that’s easy for you, do it right away. When you come to a problem that’s hard, skip it. When you’ve looked through the whole sheet and finished the easy problems, then go back to the beginning and try the harder ones.***

We will score these worksheets by looking at each number, or digit, in your solution. That way, you can earn partial credit even if your answer isn’t completely correct. As you solve the problems, please write fractions in lowest terms (reduce/simplify them). When you complete a division problem, write the remainder as a decimal and round your answer to two places (hundredths). You can convert improper fractions to mixed numbers OR leave them as improper fractions. Either form of the correct answer will earn full credit.

Now we’ll take a minute so you can practice doing some Computation problems. If you finish before I say ‘Stop’, please do NOT turn to the next page. Any questions?

Ready, begin. [Time for 1 minute—watch clock or watch]

Stop. Please put your pencils down.

Now that you’ve had a chance to try out this type of activity, do you have any questions? [Only answer procedural questions—do not suggest ways to solve the problems.]

Now we’ll do the first of two Computation sheets. You will have *5* ***minutes to work on each one***. ***Remember, your job is to answer as many problems correctly as you can in 5 minutes. Please look at each problem, but if you do not know how to do it, skip it and move on. If you get to the STOP page, remember to stop there.***

****When I say begin, please turn past the sample/STOP page and start working. Remember to start with the easy problems and then go back to the problems that are more difficult. You will have 5 minutes. Do your best work.***

Ready, (Pause) ***begin.*** [Start timer. Time for 5 minutes.] When the timer goes off, say, ***Stop. Please put your pencils down. If you haven’t turned to the red STOP page, please do so now. [Now we will do the second Computation sheet.]*** [REPEAT FROM * FOR SECOND SHEET.]

Now we will shift gears to a different type of activity. Please turn past the STOP page to the page that says Estimation at the top.

Estimation
Standard Directions

Set timer to 3 minutes.

“***The second type of activity you will be doing is called Estimation.*** [Hold up booklet with Estimation sample page showing.] ***This sample page shows some examples of the types of problems. Here’s how you complete this activity. Read the problem and estimate the answer. DO NOT take time to calculate an exact answer. Look at the three choices at the bottom of the box and decide which one is the best estimate for the correct answer. If you’re not sure about an answer, it is better to skip the problem than to take a wild guess. If you do too much guessing, you will lose points on this worksheet. Now look at Problem A. You should first read the problem, 94 and one tenth minus 29 and four tenths, and estimate the answer. The answer is about 60, so the best estimate is 60. Now look at problem B. What is the correct answer to Problem B?*** [Wait for students to volunteer 20]. ***Yes, that’s correct. 20 is about half of 42.***

Now we’ll take a minute so you can practice doing an estimation worksheet. When you do these problems, please start here [point to upper left corner of 8 sample problems at the bottom of the page] ***and move across each row from left to right*** [demonstrate]. ***When I say begin, please work on the 8 practice problems at the bottom of the sample page. If you finish before I say ‘Stop’, please do NOT turn to the next page. Any questions?***

Ready, begin. [Time for 1 minute—watch clock or watch]

Stop. Please put your pencils down.

Now that you’ve had a chance to try out this type of activity, do you have any questions? [Only answer procedural questions—do not suggest ways to solve the problems.]

Now we’ll do the first of two Estimation tasks. **Each one is two pages long.** (Emphasize that this one has TWO pages before the STOP page!) ***You will have*** *3* ***minutes to work on this activity***. ***Remember, your job is to answer as many problems correctly as you can in 3 minutes. You DO NOT need to figure out an exact answer. Use mental math to choose the best estimate. Remember that it is better to skip a problem if you’re not sure of the answer than to take a wild guess. Please look at each problem, but if you do not know how to do it, skip it and move on. If you get to the end of the worksheet before the time is up, go back and work on the more difficult problems. If you get to the STOP page, remember to stop there.***

****When I say begin, please turn past the sample/STOP page and start working. You will have 3 minutes. Do your best work.***

Ready, (Pause) ***begin***. [Start timer. Time for 3 minutes.] When the timer goes off, say, ***Stop. Please put your pencils down. If you haven’t turned to the red STOP page, please do so now. [Now we will do the second Estimation activity.]*** [REPEAT FROM * FOR SECOND PROBE.]

Now we will shift to our third, and final type of activity. Please turn past the STOP page to the page that says Complex Quantity Discrimination at the top.

Complex Quantity Discrimination
Standard Directions

Set timer to 1 minute.

"***The last type of activity you will be doing today is called a Complex Quantity Discrimination worksheet.*** [Hold up booklet with Complex Quantity Discrimination sample page showing.] ***This sample page shows some examples of the types of problems on the worksheet. For each problem, you will look at the two quantities and then write greater than, less than, or equal to in the box.*** [As you say each term, write the corresponding symbol on the board: >, <, =] ***You can see that problem A has been answered. 60 plus 5 is <u>less than</u> 61 plus 5, so the correct answer is <u>less than</u>. Now look at problem B. The two quantities are 60 times 5 and 5 times 60. The dot between the two numbers is a symbol for multiplication. What is the correct answer to problem B?*** [Wait for students to volunteer <u>*equal to*</u>]. ***Yes, that's correct. The correct answer is equal to, so you would write an equal sign in the box.***

Now we'll take some time, about 20 seconds, so you can practice doing some Complex Quantity Discrimination problems. If you finish before I say 'Stop', please do NOT turn to the next page. Any questions?

Ready, begin. [Time for 20 seconds—watch clock or watch]

Stop. Please put your pencils down.

Now that you've had a chance to try out this type of activity, do you have any questions? [Only answer procedural questions—do not suggest ways to solve the problems.]

Now we'll do the first of two Complex Quantity Discrimination worksheets. You will have 1 minute to work on this activity. Remember, your job is to answer as many problems correctly as you can in 1 minute. Please look at each problem, but if you do not know how to do it, skip it and move on. If you get to the end of the page before the time is up, go back and work on the more difficult problems. If you get to the STOP page, remember to stop there.

****When I say begin, please turn past the sample/STOP page and start working. You will have 1 minute. Do your best work.***

Ready, (Pause) ***begin.*** [Start timer. Time for 1 minute.] When the timer goes off, say, ***Stop. Please put your pencils down. If you haven't turned to the red STOP page, please do so. [Now we will do the second Complex Quantity Discrimination worksheet.]*** [REPEAT FROM * FOR SECOND PROBE.]

After the second probe, say, ***This is the end of the math assessments for today. THANK YOU for your hard work! Please close up your booklets and hand them in.***

Research Institute Progress Monitoring (RIPM)
2006-2007
Middle School Measures Study

General Introduction to Progress Monitoring

Standard Directions – Day 2

"Good morning/afternoon! My name is ______________ and I'm part of the math progress monitoring research team at Iowa State University. As you know, your class and other math classes here at XXX Middle School are working with ISU on a project to learn more about how brief assessments can be used to help teachers do an even better job of helping students learn mathematics. Today you will complete the second set of worksheets for the project. Remember that all students will be completing the worksheets, but your scores will only be used for the research project if both you and your parent/guardian have given permission.

Before we begin, remember that you will have limited time for each of these activities. The object is to complete as many questions correctly as you can in the time provided. Please do your best work on each activity so we can best figure out which types of assessments are most helpful to your teachers.

Do you have any questions at this point?" **[**Pause and respond to any student questions. HAND OUT STUDENT BOOKLETS.]

This booklet contains the worksheets you will be doing today. Please fill in the information on the front cover and print so that we will be able to read what you write. [Pause and allow students to finish. Monitor to see that they are including the needed information, but not writing anything in the 'For Researcher Use' section at the bottom.

Just as we did with the first set of activities, we will start with a sample page. This page will have questions similar to the questions on the worksheet. We will also do a short exercise in which you can practice answering these types of questions. Think of the sample pages as 'warm-up' activities to get you ready to do your best on the worksheets. At the end of each activity, you will see a red page with a stop sign on it. This tells you that you have come to the end of this activity and should not turn any farther in the book. The STOP pages look like this [hold up example]. ***Please open your booklet to the first page.***

MBSP Concepts and Applications
Standard Directions

Set timer to 7 minutes.

"***The first type of activity you will be doing is a Concepts and Applications task.*** [Hold up booklet with Concepts and Applications sample page showing.] ***This sample page shows some examples of the types of problems you'll be doing. This activity has many different kinds of problems, including multiple choice problems, story problems, and problems where you need to read charts and graphs. Look at sample problem A. On this problem, you need to read the thermometer to answer the question. What do you think the correct answer is?*** [Pause and allow students to work out the problem; solicit a volunteer to answer.] ***Yes, that's correct. The temperature started at 4 degrees and increased to 12 degrees. The number of degrees it increased is 8. Now try problem B.*** [Pause as students work.] ***What is the answer to problem B?*** [Wait for students to volunteer $142.58]. ***Yes, that's correct.***

Here's how you take this test. Start here (point to the upper left corner) ***and move down each column*** (demonstrate). ***When you come to a problem that's easy for you, do it right away. When you come to a problem that's hard, skip it. When you've looked through the whole test and finished the easy problems, then go back to the beginning and try the harder ones.***

We will score these tests by looking at each answer you give. As you work the problems, please write fractions in lowest terms (reduce/simplify them). When you do a problem that involves money, remember to use a dollar sign in your answer.

Now we'll take a minute so you can practice doing some Concepts and Applications problems. If you finish before I say 'Stop', please do NOT turn to the next page. Any questions?

Ready, begin. [Time for 1 minute—watch clock or watch]

Stop. Please put your pencils down.

Now that you've had a chance to try out this type of activity, do you have any questions? [Only answer procedural questions—do not suggest ways to solve the problems.]

Now we'll do the first of two Concepts and Applications activities. Each one is three pages long. You will have 7 minutes to work on each one. Remember, your job is to answer as many problems correctly as you can in 7 minutes. Please look at each problem, but if you do not know how to do it, skip it and move on. If you get to the STOP page and have worked all the problems you can, remember to stop there.

****When I say begin, please turn past the sample/STOP page and start working. Remember to start with the easy problems and then go back to the problems that are more difficult. You will have 7 minutes. Do your best work.***

Ready, (Pause) ***begin.*** [Start timer. Time for 7 minutes.] When the timer goes off, say, ***Stop. Please put your pencils down. If you haven't turned to the red STOP page, please do so now. [Now we will do the second Concepts and Applications activity.]*** [REPEAT FROM * FOR SECOND PROBE.]

Now we will shift gears to a different type of activity. Please turn past the STOP page to the page that says Basic Facts at the top.

Basic Facts
Standard Directions

Set timer to 1 minute.

*"**The next type of activity that you will be doing is a Basic Facts worksheet.*** [Hold up booklet with Basic Facts sample page showing.] ***This sample page shows some examples of the types of problems on the worksheet. For each problem, you will write the answer. You can see that problem A has been answered. 13 minus 9 is 4 and that is the answer given. What is the correct answer to problem B, 7 times 9?*** [Wait for students to volunteer 63]. ***Yes, that's correct. The correct answer is 63.***

Now we'll take some time, about 20 seconds, so you can practice doing a Basic Facts worksheet. If you finish before I say 'Stop', please do NOT turn to the next page. Any questions?

Ready, begin. [Time for 20 seconds—watch clock or watch]

Stop. Please put your pencils down.

Now that you've had a chance to try out this type of activity, do you have any questions? [Only answer procedural questions—do not suggest ways to solve the problems.]

Now we'll do the first of two Basic Facts worksheets. You will have 1 minute to work on each one. Remember, your job is to answer as many problems correctly as you can in 1 minute. Please look at each problem, but if you do not know how to do it, skip it and move on. If you get to the end of the page before time is up, go back and work on the more difficult problems. If you get to the STOP page, remember to stop there.

****When I say begin, please turn past the sample/STOP page and start working. You will have 1 minute. Do your best work.***

Ready, (Pause) ***begin.*** [Start timer. Time for 1 minute.] When the timer goes off, say, ***Stop. Please put your pencils down. If you haven't turned to the red STOP page, please do so now. [Now we will do the second Basic Facts worksheet.]*** [REPEAT FROM * FOR SECOND PROBE.]

Now we will shift to our third, and final type of activity. Please turn past the STOP page to the page that says Missing Number at the top.

Missing Number
Standard Directions

Set timer to 2 minutes.

"***The last type of activity you will be doing is called Missing Number.*** [Hold up booklet with Missing Number sample page showing.] ***This page shows some examples of the types of problems. For each problem, you need to look at the three numbers and try to figure out the missing number in the pattern. You can see that problem A has been answered. 63, 81, and 90 are all multiples of 9, so the correct answer is 72. Now look at problem B. The numbers are 26, 29, and 32. What number would come next in this pattern?*** [Wait for students to volunteer 35]. ***Yes, that's correct. The correct answer is 35, because the pattern is increasing by 3, so you would write 35 on the line.***

Now we'll take some time, about 40 seconds, so you can practice doing a Missing Number worksheet. If you finish before I say 'Stop', please do NOT turn to the next page. Any questions?

Ready, begin. [Time for 40 seconds—watch clock or watch]

Stop. Please put your pencils down.

Now that you've had a chance to try out this type of activity, do you have any questions? [Only answer procedural questions—do not suggest ways to solve the problems.]

Now we'll do the first of two Missing Number worksheets. You will have 1 minute to work on each one. Remember, your job is to answer as many problems correctly as you can in 2 minutes. Please look at each problem, but if you do not know how to do it, skip it and move on. If you get to the end of the worksheet before the time is up, go back and work on the more difficult problems. If you get to the STOP page, remember to stop there.

****When I say begin, please turn past the sample/STOP page and start working. You will have 2 minutes. Do your best work.***

Ready, (Pause) ***begin.*** [Start timer. Time for 2 minutes.] When the timer goes off, say, ***Stop. Please put your pencils down. If you haven't turned to the red STOP page, please do so. [Now we will do the second Missing Number worksheet.]*** [REPEAT FROM * FOR SECOND PROBES.]

After the second probe, say, ***This is the end of the math assessments. THANK YOU for your hard work this week! Please close up your booklets and hand them in.***

Appendix B

Teacher Rating Form

Teacher ______________________

Middle School Math Progress Monitoring Study
Berg Middle School
Spring 2007

Directions: For each student, rate his or her general proficiency in mathematics relative to other students in your class(es). A rating of "1" indicates a very low level of proficiency, "4" indicates average proficiency, and "7" indicates exceptional proficiency. Try to spread student ratings across the full range of the scale, not clustering students only in the middle or toward one end.

Student		Mathematics Proficiency						
Last Name	First Name	Low			Average			High
		1	2	3	4	5	6	7
		1	2	3	4	5	6	7
		1	2	3	4	5	6	7
		1	2	3	4	5	6	7
		1	2	3	4	5	6	7
		1	2	3	4	5	6	7
		1	2	3	4	5	6	7
		1	2	3	4	5	6	7
		1	2	3	4	5	6	7
		1	2	3	4	5	6	7
		1	2	3	4	5	6	7
		1	2	3	4	5	6	7
		1	2	3	4	5	6	7
		1	2	3	4	5	6	7
		1	2	3	4	5	6	7
		1	2	3	4	5	6	7
		1	2	3	4	5	6	7
		1	2	3	4	5	6	7
		1	2	3	4	5	6	7
		1	2	3	4	5	6	7
		1	2	3	4	5	6	7
		1	2	3	4	5	6	7
		1	2	3	4	5	6	7
		1	2	3	4	5	6	7
		1	2	3	4	5	6	7
		1	2	3	4	5	6	7
		1	2	3	4	5	6	7
		1	2	3	4	5	6	7
		1	2	3	4	5	6	7
		1	2	3	4	5	6	7