

Using Lagging Indicators to Predict Grade 6 Performance on the Maryland School Assessment in Mathematics

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Abstract

This research brief describes a model that correctly predicts mathematics performance (basic vs. proficient or above) on the Maryland School Assessment (MSA) for approximately 90% of students.

Background

Goal 1 of the Montgomery County Public Schools (MCPS) strategic plan is to ensure success for every student (MCPS, 2006). Although MCPS is making progress toward attainment of this goal, one area that continues to be the focus of improvement efforts is student performance in middle school mathematics.

MCPS administrators and instructors increasingly are invested in identifying tools and methods that can help determine the likelihood of a student attaining proficiency on the Maryland School Assessment (MSA). Having this information at the beginning of the school year can facilitate instructional planning for all students and allow interventions to begin earlier for students in need of assistance.

Using student information available before the beginning of the school year (i.e., lagging indicators), this study seeks to integrate the information from several indicators to provide predictions of performance with more accuracy than can be obtained from single indicators. This study addresses two research questions:

1. What combination of lagging indicators is useful for predicting Grade 6 MSA mathematics scores and performance levels?
2. How accurate are the performance level predictions for all students and for different student groups?

Methodology

Students (N=9,132) who took the 2006 Grade 6 MSA in mathematics, and the 2005 Grade 5 MSA in mathematics and reading while enrolled in MCPS were included in the study.

The prediction model was developed in two steps. The first step was to predict students' Grade 6 MSA mathematics scale scores. The second step was to identify two "cuts" for the predicted scores that define the borders for adjacent MSA performance levels (basic/proficient and proficient/advanced).

The variables used to develop the prediction model were selected because of their strong association with academic achievement (Abedi, 2002; Ding & Davison, 2005; Dunn, Kadane, & Garrow, 2003; Harwell, Post, Maeda, Davis, Cutler, Andersen, & Kahan, 2007; Hofstetter, 2003; McCoy & Reynolds, 1999; Wiliam & Bartholomew, 2004) and their availability in MCPS databases. The following variables were included in multiple regression models to predict Grade 6 MSA mathematics scores:

- Grade 5 MSA mathematics score
- Grade 4 MSA mathematics score
- Grade 5 MSA reading score
- Grade 5 attendance rate
- Grade 6 mathematics course (above grade level or not)
- Combination of Grade 6 mathematics course and Grade 5 MSA mathematics score

Grade 6 demographic status (gender, race/ethnicity, participation in Free and Reduced-price Meals System [FARMS], special education, and Limited English Proficiency [LEP] services) and Grade 4 MSA reading scores were examined as predictors but were not included in the final model because they did not improve prediction accuracy.

To include as many students as possible in the sample, Grade 4 MSA scores were estimated for the approximately 650 Grade 6 students who did not have Grade 4 MSA data (Graham & Hofer, 2000). Generalized estimating equations were used to estimate the final model parameters.

Cut scores for assigning students to predicted performance levels were identified based on the resulting model accuracy and prediction error for all

demographic groups. The cut scores selected for predicted scores are slightly higher than the cut scores for the Grade 6 MSA mathematics set by the Maryland State Department of Education (MSDE) because the upward adjustment results in better performance of the prediction model.

Results

Lagging Indicators for Predicting MSA Performance

A weighted average of six lagging indicators was most useful for predicting Grade 6 MSA mathematics scores and performance levels. Those lagging indicators are (1) Grade 5 MSA mathematics score, (2) Grade 4 MSA mathematics score, (3) Grade 5 MSA reading score, (4) Grade 5 attendance rate, (5) Grade 6 mathematics course (above grade level or not), and (6) the combination of Grade 6 mathematics course and Grade 5 MSA mathematics score.

Prediction Accuracy for MSA Performance Levels

Prediction accuracy is calculated as the percentage of students whose predicted Grade 6 MSA mathematics performance level matches their actual performance level. Prediction errors occur when students perform below their predicted level or when students perform above their predicted level.

Basic vs. proficient or above. Table 1 shows the accuracy and error rates by demographic group for predicting two MSA performance levels—basic vs. proficient or above. The model correctly predicts

Table 1
Predicting Basic vs. Proficient or above
for 2006 Grade 6 MSA Mathematics
by Demographic Group¹

Basic vs. Proficient or above	Total N	% Correct Pred.	% Worse than Pred.	% Better than Pred.
All Students	9,132	90.6	4.2	5.2
Male	4,693	91.2	4.3	4.5
Female	4,439	89.9	4.1	6.0
African Am.	1,981	85.9	6.2	7.9
Asian	1,359	93.8	2.5	3.7
Hispanic	1,746	84.1	6.1	9.8
White	4,024	94.6	3.0	2.5
FARMS	2,143	84.3	6.2	9.6
Special Education	1,136	85.6	5.7	8.7
LEP ²	751	83.9	3.7	12.4

¹ American Indian student results not reported separately.

² LEP subgroup defined for *No Child Left Behind Act of 2001* (NCLB) accountability.

those two performance levels for 90.6% of the students. Overall, when the prediction is wrong, students are more likely to perform better than the predicted level rather than worse than predicted.

The model performs satisfactorily for the different demographic groups. Accuracy rates for predicting the MSA performance levels, basic vs. proficient or above, range from 83.9% to 94.6% among the groups. However, lower accuracy rates are expected for groups that have more students near the cut score. For this reason, Hispanic, African American, and groups of students receiving LEP, special education, or FARMS services have accuracy rates in the 84–86% range. White and Asian students have accuracy rates in the 94–95% range.

Error rates are important when evaluating model performance. First, the error rates for students performing worse than predicted are low for all groups and vary within two percentage points of the overall rate of 4.2% for that type of error. Secondly, for nearly all groups, when predictions are wrong, students were more likely to perform better than predicted. The group with the opposite pattern, White students, has error rates below those of the cohort and the highest accuracy rate.

Advanced vs. proficient or below. The model correctly predicts two MSA performance levels—advanced vs. proficient or below, for 88.3% of all students (Table 2). White and Asian groups, with more students near the advanced cut score, have accuracy rates near 84%. African American, Hispanic, and groups of students receiving LEP,

Table 2
Predicting Advanced vs. Proficient or below
for 2006 Grade 6 MSA Mathematics
by Demographic Group¹

Advanced vs. Proficient or below	Total N	% Correct Pred.	% Worse than Pred.	% Better than Pred.
All Students	9,132	88.3	4.4	7.3
Male	4,693	88.0	4.1	7.9
Female	4,439	88.6	4.8	6.6
African Am.	1,981	94.3	1.8	3.8
Asian	1,359	84.5	4.2	11.3
Hispanic	1,746	94.7	2.0	3.3
White	4,024	83.9	6.9	9.2
FARMS	2,143	95.5	1.5	3.0
Special Education	1,136	95.1	1.1	3.8
LEP ²	751	95.5	0.4	4.1

¹ American Indian student results not reported separately.

² LEP subgroup defined for NCLB accountability.

special education, or FARMS services have accuracy rates over 94%. For all student groups, when predictions are wrong, students are more likely to perform better than predicted.

Basic vs. proficient vs. advanced. Accuracy rates will drop when predicting three levels of performance rather than two. The error for predicting three levels is at least the sum of the errors at each cut score. Predictions for all three performance levels (basic, proficient, or advanced) are correct for 78.9% of the students, with 12.4% of students attaining a performance level higher than predicted and only 8.6% of students earning a performance level below predicted (Appendix Table A1).

Discussion

This model provides a prediction of MSA Grade 6 mathematics performance from data known at the beginning of the school year. The high accuracy rates (90.6% for distinguishing between basic vs. proficient and above, and 88.3% for distinguishing between advanced vs. proficient and below) and good model performance for all demographic groups makes it a useful tool for prediction of all three performance levels.

Given the high accuracy rates of the model, one might wonder whether a student's prior performance and attendance necessarily seals the fate of his/her MSA score earned the following year. The student's predicted score should be interpreted as the best estimate of the student's performance score rather than the student's predetermined score.

The model cannot tell for which students its prediction will be wrong—or why. For example, the Grade 6 educational experience can have a profound impact on students' performance. What kinds of instruction can boost student performance over and above what is predicted? District, school, and classroom leadership should view predicted scores as one way to gauge students' instructional needs and consider other indicators of students' learning throughout the school year to monitor progress.

These analyses have been extended to produce MSA mathematics performance prediction models for Grades 7 and 8. The performance of these models and results of their validation with data of 2006–2007 are provided in the Appendix.

Recommendation

Predictions should serve as a catalyst for a team to intervene appropriately so that more students will move from basic to proficient and from proficient to

advanced. When making decisions about interventions, keep in mind that the student's predicted MSA score will not match the student's observed MSA score exactly. It is recommended to allow for about 20 points on either side of the predicted score for the student's predicted score range.

Differences between student cohorts and changes in the assessments and/or instructional practices over time could affect the accuracy of the prediction model. The Department of Shared Accountability should continue to monitor model performance each year and update the model as needed. In addition, models predicting MSA reading performance could be developed for Grades 6 through 8.

Multivariate models such as these may be integrated into tools used by school personnel to compare the predicted and observed performance levels of their students. This will allow staff to study patterns of correct and incorrect predictions and connect how practices impact students' performance.

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Table A1
Performance of Model for Predicting Performance Levels for Grade 6 MSA Mathematics by Demographic Group

Grade 6 Cohort	Demographic Group ¹	Total <i>N</i>	Predicting Proficient or above vs. Basic (2 Groups)			Predicting Advanced vs. Proficient or below (2 Groups)			Predicting Basic vs. Proficient vs. Advanced (3 Groups)		
			% Correct Prediction	% Worse than Predicted	% Better than Predicted	% Correct Prediction	% Worse than Predicted	% Better than Predicted	% Correct Prediction	% Worse than Predicted	% Better than Predicted
2005–2006	All Students	9,132	90.6	4.2	5.2	88.3	4.4	7.3	78.9	8.6	12.4
	Male	4,693	91.2	4.3	4.5	88.0	4.1	7.9	79.2	8.4	12.4
	Female	4,439	89.9	4.1	6.0	88.6	4.8	6.6	78.6	8.9	12.5
	African Am.	1,981	85.9	6.2	7.9	94.3	1.8	3.8	80.4	7.9	11.7
	Asian	1,359	93.8	2.5	3.7	84.5	4.2	11.3	78.4	6.7	14.9
	Hispanic	1,746	84.1	6.1	9.8	94.7	2.0	3.3	78.8	8.1	13.1
	White	4,024	94.6	3.0	2.5	83.9	6.9	9.2	78.5	9.8	11.7
	FARMS	2,143	84.3	6.2	9.6	95.5	1.5	3.0	79.9	7.7	12.5
	Special Education	1,136	85.6	5.7	8.7	95.1	1.1	3.8	80.7	6.8	12.5
	LEP ²	751	83.9	3.7	12.4	95.5	0.4	4.1	79.4	4.1	16.5
2006–2007 ³	All Students	9,198	88.9	4.8	6.4	86.9	3.8	9.4	75.8	8.5	15.7
	Male	4,666	88.9	5.2	6.0	87.1	3.6	9.3	76.0	8.7	15.3
	Female	4,532	88.8	4.3	6.8	86.6	4.0	9.4	75.5	8.3	16.2
	African Am.	2,069	82.6	6.7	10.6	92.4	1.7	5.9	75.1	8.4	16.5
	Asian	1,363	94.1	2.4	3.5	85.0	2.9	12.2	79.2	5.1	15.6
	Hispanic	1,816	82.6	6.6	10.8	92.0	2.0	6.0	74.6	8.5	16.9
	White	3,922	93.2	3.6	3.1	82.2	5.9	11.8	75.5	9.6	14.9
	FARMS	2,365	81.7	6.8	11.5	93.0	1.3	5.7	74.7	8.1	17.3
	Special Education	1,234	80.5	6.6	12.9	95.1	1.5	3.3	75.7	8.2	16.1
	LEP ²	819	80.0	6.5	13.6	94.7	0.6	4.6	74.8	7.0	18.2

¹ American Indian student results not reported separately.

² LEP subgroup defined for *No Child Left Behind Act of 2001* (NCLB) accountability.

³ Data of 2006–2007 cohort was used to validate the model developed from data of 2005–2006 cohort.

Table A2
Performance of Model for Predicting Performance Levels for Grade 7 MSA Mathematics by Demographic Group

Grade 7 Cohort	Demographic Group ¹	Total <i>N</i>	Predicting Proficient or above vs. Basic (2 Groups)			Predicting Advanced vs. Proficient or below (2 Groups)			Predicting Basic vs. Proficient vs. Advanced (3 Groups)		
			% Correct Prediction	% Worse than Predicted	% Better than Predicted	% Correct Prediction	% Worse than Predicted	% Better than Predicted	% Correct Prediction	% Worse than Predicted	% Better than Predicted
2005–2006	All Students	9,324	90.5	4.2	5.3	90.1	3.5	6.4	80.6	7.7	11.8
	Male	4,720	89.9	4.3	5.8	90.5	3.4	6.2	80.4	7.7	11.9
	Female	4,604	91.1	4.1	4.9	89.7	3.6	6.7	80.8	7.6	11.6
	African Am.	2,092	86.8	6.1	7.1	95.6	1.6	2.9	82.4	7.6	10.0
	Asian	1,349	94.6	2.1	3.3	87.2	4.1	8.7	81.8	6.2	11.9
	Hispanic	1,752	83.6	6.4	10.0	95.1	1.8	3.1	78.7	8.2	13.1
	White	4,100	93.9	3.0	3.1	86.1	4.9	8.9	80.1	7.9	12.0
	FARMS	2,091	84.9	6.1	9.0	95.9	1.2	2.9	80.9	7.3	11.9
	Special Education	1,194	88.3	3.9	7.9	97.2	0.8	2.0	85.6	4.5	9.9
	LEP ²	660	84.2	5.5	10.3	94.8	0.2	5.0	79.1	5.6	15.3
2006–2007 ³	All Students	9,210	89.7	4.2	6.1	89.5	4.3	6.1	79.2	8.6	12.2
	Male	4,719	89.6	4.5	5.9	89.5	4.5	6.0	79.1	9.0	11.9
	Female	4,491	89.7	3.9	6.3	89.6	4.2	6.2	79.4	8.1	12.5
	African Am.	2,027	85.2	6.8	8.0	95.3	2.2	2.5	80.5	9.0	10.5
	Asian	1,387	94.7	1.8	3.5	86.2	4.4	9.4	81.0	6.2	12.8
	Hispanic	1,783	84.2	5.8	10.0	93.9	1.7	4.4	78.1	7.5	14.4
	White	3,988	92.6	3.1	4.3	85.8	6.6	7.6	78.4	9.7	11.9
	FARMS	2,251	84.1	5.4	10.5	95.6	1.4	2.9	79.7	6.8	13.4
	Special Education	1,085	85.1	2.9	12.0	95.7	1.4	2.9	80.8	4.3	14.8
	LEP ²	633	86.1	3.6	10.3	95.1	0.2	4.7	81.2	3.8	15.0

¹ American Indian student results not reported separately.

² LEP subgroup defined for *No Child Left Behind Act of 2001* (NCLB) accountability.

³ Data of 2006–2007 cohort was used to validate the model developed from data of 2005–2006 cohort.

Table A3
Performance of Model for Predicting Performance Levels for Grade 8 MSA Mathematics by Demographic Group

Grade 8 Cohort	Demographic Group ¹	Total N	Predicting Proficient or above vs. Basic (2 Groups)			Predicting Advanced vs. Proficient or below (2 Groups)			Predicting Basic vs. Proficient vs. Advanced (3 Groups)		
			% Correct Prediction	% Worse than Predicted	% Better than Predicted	% Correct Prediction	% Worse than Predicted	% Better than Predicted	% Correct Prediction	% Worse than Predicted	% Better than Predicted
2005–2006	All Students	9,763	89.9	4.3	5.8	90.7	3.9	5.4	80.7	8.1	11.2
	Male	5,073	89.7	4.2	6.1	90.9	3.9	5.3	80.7	8.0	11.3
	Female	4,690	90.1	4.4	5.5	90.6	3.8	5.6	80.7	8.2	11.1
	African Am.	2,142	87.1	5.7	7.2	94.1	2.1	3.8	81.1	7.9	11.0
	Asian	1,429	93.3	3.0	3.7	90.6	3.4	6.1	83.9	6.3	9.8
	Hispanic	1,731	85.4	4.9	9.7	93.4	2.5	4.1	78.7	7.5	13.8
	White	4,437	92.0	3.7	4.3	88.2	5.3	6.5	80.3	9.0	10.8
	FARMS	2,016	87.3	4.4	8.4	95.3	1.6	3.1	82.5	6.0	11.5
	Special Education	1,212	88.0	3.2	8.8	96.6	1.4	2.0	84.7	4.6	10.7
	LEP ²	560	87.5	1.8	10.7	93.4	0.9	5.7	80.9	2.7	16.4
2006–2007 ³	All Students	9,454	89.5	4.2	6.3	89.8	4.5	5.7	79.4	8.6	12.0
	Male	4,804	89.9	4.1	6.0	90.0	4.7	5.3	80.1	8.7	11.2
	Female	4,650	89.0	4.3	6.7	89.5	4.4	6.1	78.7	8.6	12.7
	African Am.	2,145	85.6	6.1	8.3	93.0	3.0	4.0	78.6	9.1	12.2
	Asian	1,380	93.3	2.6	4.1	90.1	4.8	5.1	83.6	7.3	9.1
	Hispanic	1,772	84.4	5.1	10.5	92.3	3.2	4.5	76.7	8.2	15.0
	White	4,126	92.3	3.4	4.3	87.0	5.8	7.3	79.6	9.0	11.5
	FARMS	2,221	85.2	5.2	9.6	93.3	2.4	4.3	78.7	7.5	13.8
	Special Education	1,145	85.9	2.6	11.5	94.9	1.2	3.8	81.0	3.8	15.2
	LEP ²	488	83.6	2.7	13.7	92.6	1.4	5.9	76.6	3.9	19.5

¹ American Indian student results not reported separately.

² LEP subgroup defined for *No Child Left Behind Act of 2001* (NCLB) accountability.

³ Data of 2006–2007 cohort was used to validate the model developed from data of 2005–2006 cohort.