

## Using historical data to predict the grades of students in Advanced Placement courses in the Milwaukee Public Schools

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This brief presents the results of ongoing collaborative work of the Office of Socially Responsible Evaluation in Education (SREed) with the Milwaukee Public Schools (MPS) around the issue of increasing student access to advanced placement (AP) courses. Increasing access to AP courses is an objective of the MPS TEAM GEAR UP initiative<sup>1</sup>, which works to improve college preparedness and access for students in eight high-need Milwaukee high schools.

A historical analysis of AP course grades suggested that as many as half (depending on the course) of MPS students who take AP courses fail the course and that many high-achieving students do not take AP. Interviews of AP teachers also revealed the process for selecting and recruiting students to take AP was inconsistent from school to school and sometimes seemed random. Based on these findings, MPS TEAM GEAR UP asked us to support their efforts to increase AP course participation by using statistical modeling to identify students likely to do well in AP courses.

In this report we summarize the results of ongoing work providing MPS with student predictions of AP performance. First we examine the accuracy of fall 2016 predicted AP course grades, provided to the district in the spring of 2016, to aid them in their student recruitment and selection efforts. Next, we present the process and results of modified statistical modeling done in the spring of 2017 to predict AP course grades for students considering taking AP in the fall of 2017.

### Predicting 2016 AP performance

#### Methods of predicting fall 2016 AP course grades

In the spring of 2016, we worked with the University of Wisconsin-Madison, Value-Added Research Center to provide schools with fall 2016 AP course grade predictions for then current 10<sup>th</sup> grade students. These lists of students included the specific expected grades students would receive, converted to a four point scale, in Math, English/Language Arts (ELA), Science, and Social Studies AP courses, should they decide to take them as 11<sup>th</sup> grade students in the fall of 2016. These predictions were based on the grades in AP courses of previous cohorts of students who passed through the district. A variety of factors were used to inform these predictions

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<sup>1</sup> <http://mps.milwaukee.k12.wi.us/en/Programs/GEAR-Up.htm>

including previous course grades, school attendance, achievement, and behavior. Together, these factors were strong historical predictors of AP course performance with  $R^2$  ranging from .21 in Science to .29 in Math.

Predictions were made for 3,447 students, representing about 70% of 10<sup>th</sup> grade students. Of the 3,447 students included in the fall 2016 predictions, 681 took at least one AP course during the fall of 2017. Of these, all but eight students had been promoted to 11<sup>th</sup> grade. Among these 681 students, 76 took a math-related AP class, 417 took ELA, 147 took science, and 519 took social studies.

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### Accuracy of fall 2016 AP course grade predictions

Figures 1 through 8 and table 1 through 4 in Appendix A present the actual grades students received in AP courses organized by the grades they were predicted to receive. These are presented both as stacked bar charts, tables, and scatter-plots. Scatter-plot figures present grades transformed into a five-point scale with F = 0, D = 1, C = 2, B = 3, and A = 4. Tables are shaded green when predicted grades were within one grade of actual grades and red when they were more than one grade. Scatter-plot figures also include linear and quadratic fit lines for the data. These lines statistically show the strength of the relationships between predicted and earned course grades. The  $R^2$  numbers in these figures summarize the strength of these relationships, with possible numbers ranging from 0.000 (no relationship) to 1.000 (perfect relationship).

The results suggest that AP course grade predictions provided a good, but rough estimate of actual earned grades during the fall of 2016, but were less effective at making exact grade predictions. Of the 1,032 AP course grade predictions, 951 (92%) actual earned grades were within one letter grade. However, only 409 (40%) of predicted grades matched the actual grade earned.

The predictions were most accurate for students expected to do poorly in AP. The majority of students who took AP courses, but were predicted to not do well, struggled. Across all subject areas, only four students took AP courses when they were predicted to earn an F grade. Although roughly equal numbers of students across subject areas were predicted to earn a D grade, fewer of these students, only four, took an AP Math or Science course than did in ELA or Social Studies. Fifty-two students who took an ELA AP course were predicted to earn a D while 54 students who took a Social Studies AP course were predicted to earn a D. Thirty (58%) of these students earned a D or F grade in their ELA class and 44 (81%) earned a D or F grade in Social Studies.

The accuracy of the predictions was less consistent regarding students predicted to earn a C grade or better. Yet, one positive finding was a significant number of students who were predicted to earn a C or B overachieved their predictions and earned an A. Of the 1,032 AP

courses predicted to result in either a C or B grade, 134 (13%) resulted in an A. On the other hand, some students predicted to earn a B or A underperformed in their class and earned a D or F. Of the 348 AP courses predicted to result in a B or A grade, 41 (12%) resulted in a D or F. Still, it is important to emphasize again that most students earned grades within one grade of what they were predicted to achieve.

An analysis of the scatter-plots fit lines suggest that the accuracy of the predicted grades depended on the subject area. There were some differences in the predictive accuracy of grades in different subject areas, with Social Studies predictions being the most accurate (linear  $R^2 = .288$ ) and Math the least (linear  $R^2 = .087$ ). Although the strength of these predictions was somewhat less than what was expected, this is likely due to the student selection process limiting who participated in AP. If more students who were predicted to earn D or F grades had taken AP, it is likely that they would have struggled, which would have increased the  $R^2$  of the predictions. For instance in ELA, 742 students were predicted to fail. Of these, only two took a class.

### Predicting 2017 AP performance

In the spring of 2017, SREed was again asked by MPS to provide them with student predictions of AP performance. This time however, they wanted predictions for both current 9<sup>th</sup> and 10<sup>th</sup> grade students. MPS also asked that our predictions be more inclusive of their student population since in the previous year, due to missing data, our statistical predictions process excluded about 30% of MPS 10<sup>th</sup> grade students. The resulting statistical modeling process used to do this is explained below.

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#### Student and AP course characteristics

Current 10<sup>th</sup> and 11<sup>th</sup> grade students who took AP classes in the fall of 2016 were used as the reference group to predict the future performance of current 9<sup>th</sup> and 10<sup>th</sup> grade students who may consider taking AP in the fall of 2017 as 10<sup>th</sup> and 11<sup>th</sup> graders. In the fall of 2016, a total of 1,946 AP courses were taken by 1,352 10<sup>th</sup> and 11<sup>th</sup> grade students in the four subject areas that are the focus on this analysis (Science, Math, English Language Arts (ELA), and Social Studies). Nine-hundred thirteen students took one AP course, 310 took two, 105 took three and 24 took four or more.

Students in AP had an average fall 2015 GPA of 2.68 and a 94.2% attendance rate. They also averaged a .58  $z$ -score on their most recent achievement assessment, suggesting that, as a group, students in AP demonstrated better than average achievement. In addition, the more AP courses students took in the fall of 2016, the better their historical grades and achievement.

Table 5 below presents the numbers of 10<sup>th</sup> and 11<sup>th</sup> grade students who took AP courses in the fall of 2016 in each subject area and the corresponding grades they were assigned in those

classes. Roughly 40% of all AP courses resulted in a grade of either a D or F. Across subject areas, 502 AP courses were taken by 10<sup>th</sup> grade students and 1,444 were taken by 11<sup>th</sup> grade students.

Table 5: 2016 Fall AP course grades by subject area

	F	D	C	B	A	Total
Science	29	51	56	54	28	218
Math	10	14	29	24	15	92
ELA	70	73	165	157	68	533
Social Studies	128	319	302	221	133	1103

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### Methods used to predict 2017 AP course grades

Using these 2016 AP course results, four predictive models were built separately for AP classes in Science, Math, ELA, and Social Studies. Several factors were tested for inclusion in each model, including school attendance rates, subject specific grades, overall GPA, and a variety of achievement scores. In an effort to be more inclusive with our predictions, and to limit missing data, only the most recent school performance data were used. Missing data in our previous prediction model were due to the use of freshman year variables to predict the AP grades of current sophomore students. To avoid this problem, data used to predict the next year AP performance of students were from the previous fall semester. So sophomore data were used to predict the AP grades of current sophomore students and freshman data were used to predict AP grades for current freshman students. Ultimately, for all course areas except ELA, the only unique predictor of success was the most recent semester GPA (fall 2015). In ELA, the model included both GPA and reading achievement z-score.

The resulting model below was used to explain fall 2016 AP course grade for student  $i$  in course subject  $j$ .

$$(\text{Fall 2016 AP course grade})_{ij} = \beta_j(\text{fall 2015 GPA})_i + e_{ij}$$

Where fall 2016 AP course grade (with grades converted to a four-point scale) is predicted by fall 2015 grades (converted into a four-point scale and then converted to a z-score). Appendix B presents these modeling results. The models were good predictors of AP course grades, with Adjusted  $R^2$  ranging from .277 in social studies to .385 in science. These simple models were significantly better predictors of AP grades than the more complex models used previously.

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### Predictions of fall 2017 AP performance for current 9<sup>th</sup> and 10<sup>th</sup> grade students

From the model results presented in Appendix B, we used the  $\beta$  values to make 2017 AP course grade predictions for current 9<sup>th</sup> and 10<sup>th</sup> grade students. For example, the social studies

prediction for a student who had a 2.5 fall semester GPA, which corresponds to a .64 z-score, would be 1.69, or a low C (see below).

The intercept	+	$\beta$	x	Fall semester GPA (z-score)	=	Predicted social studies AP grade
1.076	+	.924	x	.641	=	1.69 (C grade)

Using this method, 2017 AP course grade predictions were made for 10,413 9<sup>th</sup> and 10<sup>th</sup> grade students. This represented significantly more students than we had been able to make predictions for the previous year (89% compared to 70%). Figure 1 presents the grades students are predicted to earn should they take an AP course in the fall of 2017 in each subject area. Based on these predictions, nearly 4,000 students (~38%) would be expected to at least pass (earning at least a C) an English Language Arts AP class, considerably more than the 533 students who took an ELA AP course in the fall of 2016. In Math and Science, closer to 2,500 would be expected to pass (~25%).

### Fall 2017 Predicted AP Course Grades

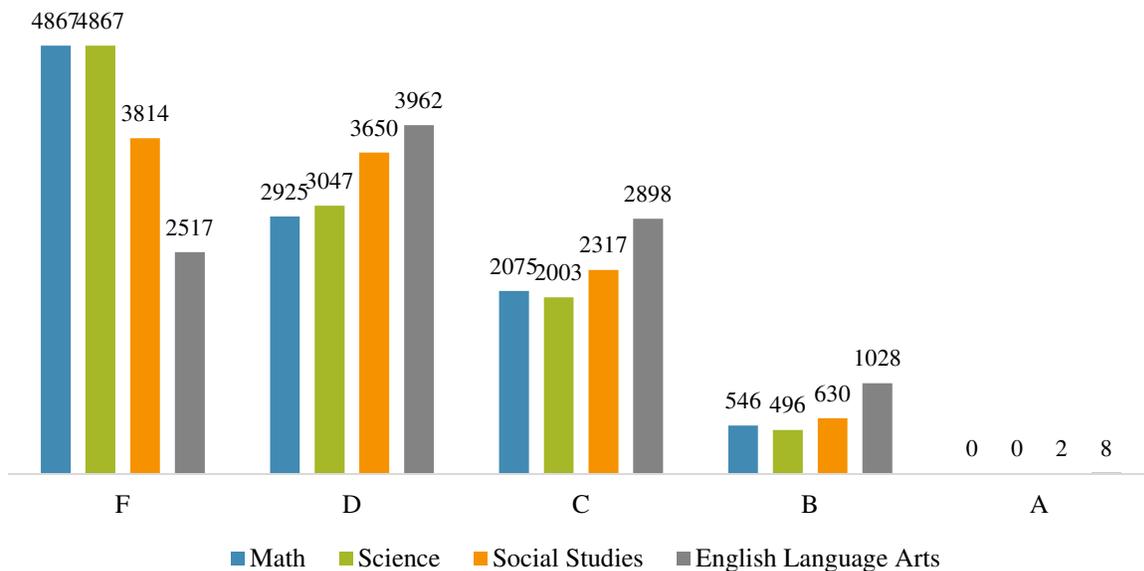


Figure 9: Predicted 2017 AP course grades for students by subject area

Figure 9 also shows that, regardless of subject, few students would be expected to earn an A grade in their AP course. This is somewhat surprising since 10% of students from the previous cohort of 10<sup>th</sup> and 11<sup>th</sup> graders earned an A in their fall 2016 AP courses. This may suggest that it

is difficult to predict exactly who is likely to earn an A since, even among the highest achieving students, many will still earn lower grades. In fact, looking at Figure 10, it is clear that many students with high GPAs over 3, still earned an F or a D in their AP course. Although nearly all students who earned an A in their AP course had high GPAs, a high GPA does not guarantee success in AP courses.

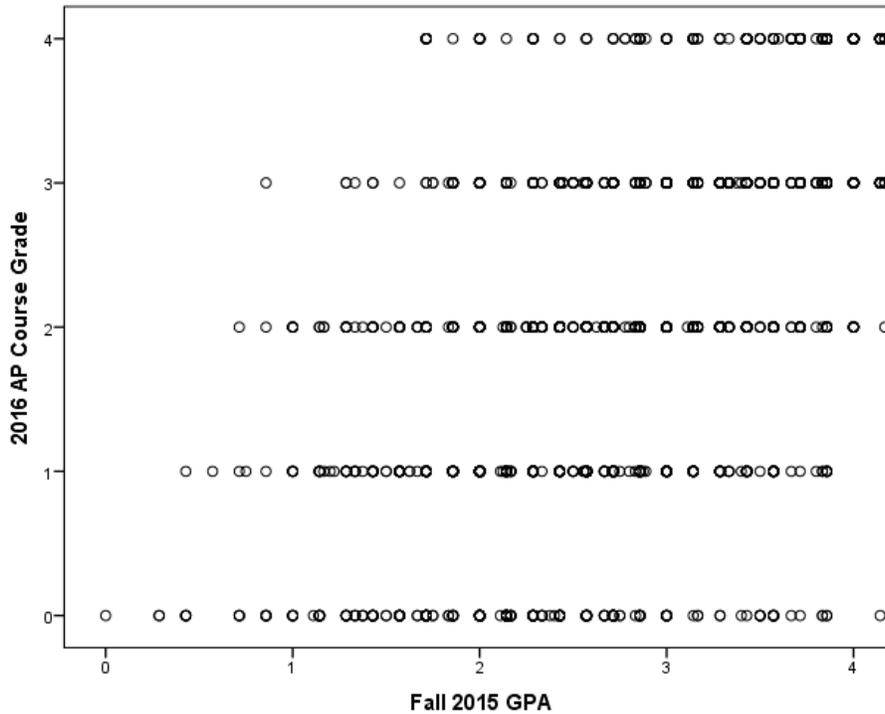


Figure 10: The relationship of 2016 AP course grades with fall 2015 GPA

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## Discussion

The results of our 2016 AP predictions suggest that they provided a good, but rough estimate of actual earned grades and were less effective at making exact grade predictions. Of the 1,032 AP course grade predictions, 951 (92%) actual earned grades were within one letter grade. However, only 409 (40%) of predicted grades matched the actual grade earned.

One challenge identified by MPS was our early predictions process excluded roughly 70% of their students. In response to this, we used the most current data possible to base our 2017 predictions. Doing so resulted in a more inclusive process that resulted in 89% coverage of current 9<sup>th</sup> and 10<sup>th</sup> grade students. Using more current data also allowed us to greatly simplify our predictive model.

The process described in this brief holds the potential for helping increase AP participation, but only if schools use the results to inform their student outreach efforts. To facilitate this, lists of individual student predictions were provided to schools and AP teachers in the spring of 2017 to

help plan for their AP course offerings and to help them recruit students for AP. It was emphasized that these predictions were not to be used to prevent students from taking AP; if students who were not expected to do well, based on their academic history, wanted to take AP, they should be encouraged to do so. However, with the knowledge that the student would likely not succeed in the class, the school would have a responsibility to provide supports to students to help them succeed.

It was also emphasized that these predictions do not replace teachers' own experiences with students. These data provide another data point, among many that could be used to identify and recruit students for AP.

It is important to point out that the information used to make these predictions is readily available to AP counselors and teachers, and already informs their AP student outreach and selection efforts. However, given the large number of students assigned to counselors, counselors may be responsible for as many as 450 students, it is useful to have transcript and achievement information summarized for all students in one place. Thus, our predictions may help counselors and teachers more easily process the information and identify additional students who would be good candidates for AP.

Additional analyses are planned in the fall of 2017 to see who ultimately enrolled in AP courses and how they performed. We also have plans to follow up with AP teachers to gather information about how these predictions were ultimately used by schools and if there are ways to make them more useful moving forward.

## Appendix A

### Accuracy of AP Predictions - Math

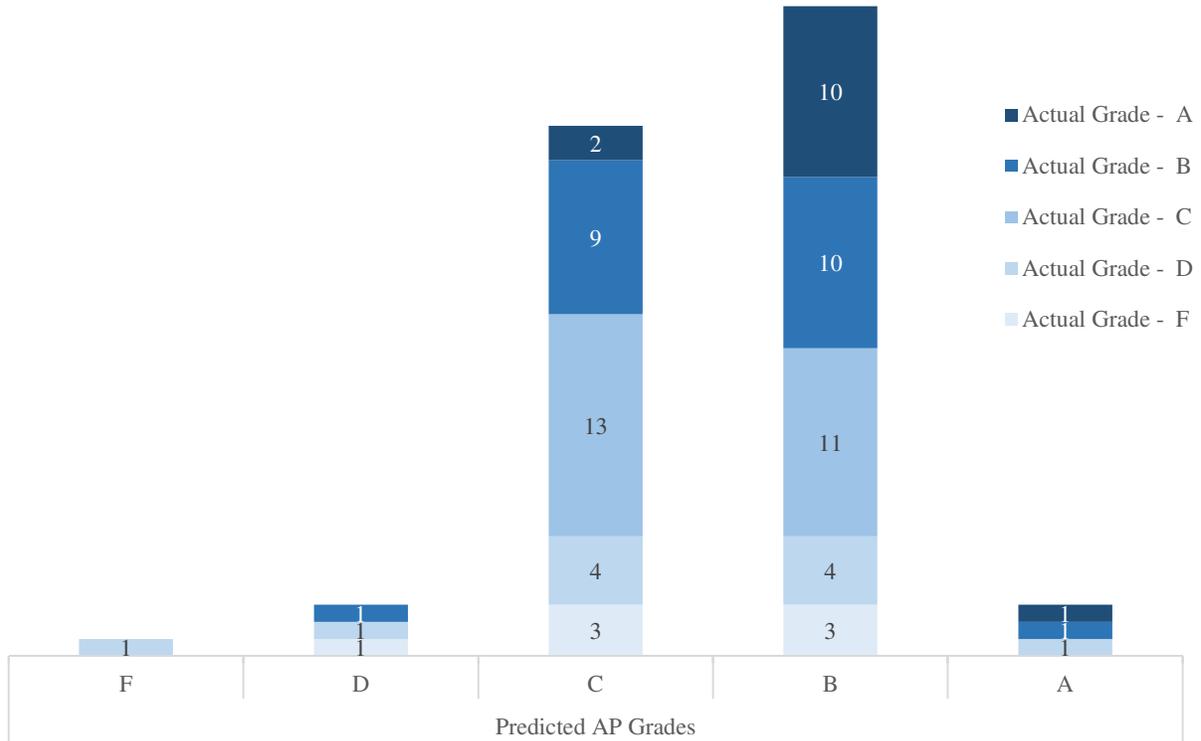


Figure 1: Cross-tabulation of predicted fall 2016 Math AP grades and actual grades

Table 1: Cross-tabulation of predicted fall 2016 Math AP grades and actual grades

		Actual grade				
		F	D	C	B	A
Predicted grade	F	0	1	0	0	0
	D	1	1	0	1	0
	C	3	4	13	9	2
	B	3	4	11	10	10
	A	0	1	0	1	1

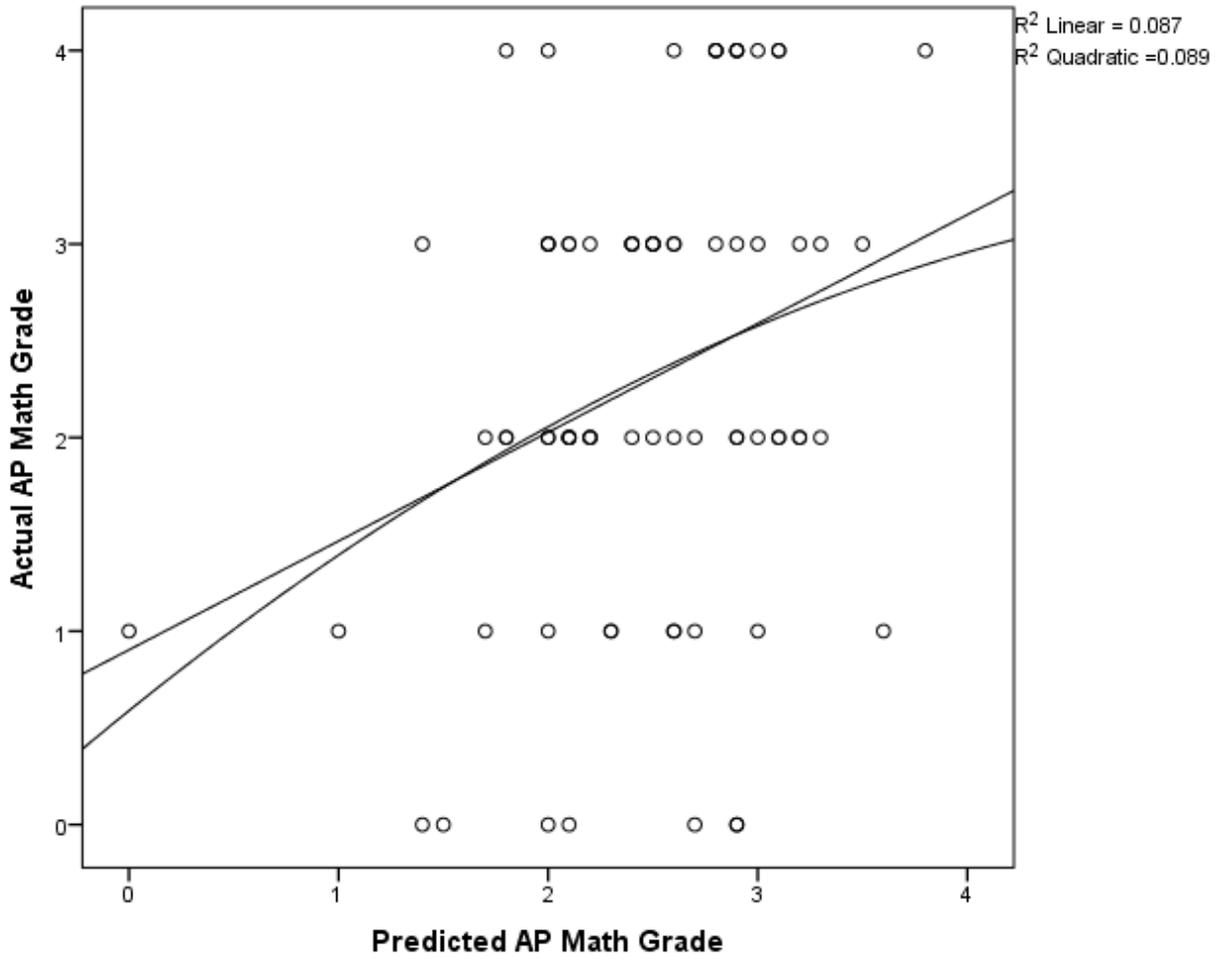


Figure 2: Scatter-plot of predicted fall 2016 Math AP grades and actual grades

### Accuracy of AP Predictions - ELA

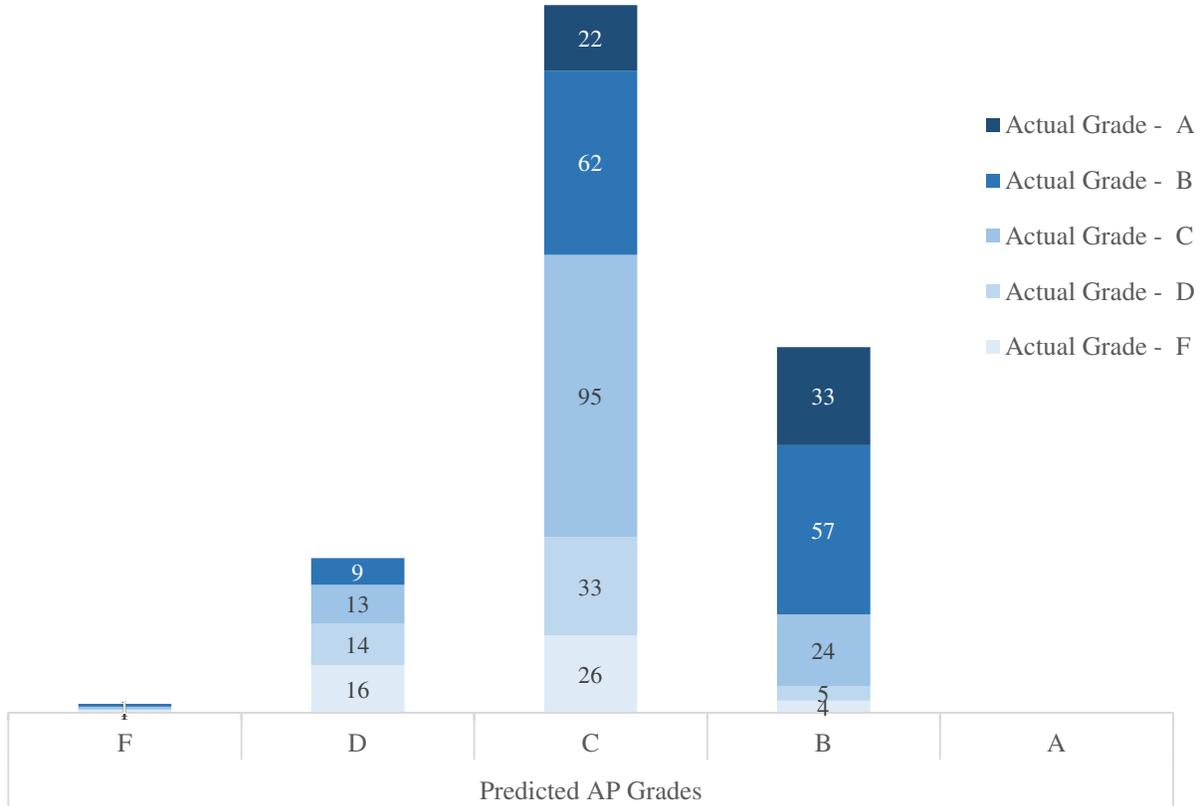


Figure 3: Cross-tabulation of predicted fall 2016 ELA AP grades and actual grades

Table 2: Cross-tabulation of predicted fall 2016 ELA AP grades and actual grades

		Actual grade				
		F	D	C	B	A
Predicted grade	F	0	0	1	1	0
	D	16	14	13	9	0
	C	26	33	95	62	22
	B	4	5	24	57	33
	A	0	0	0	0	0

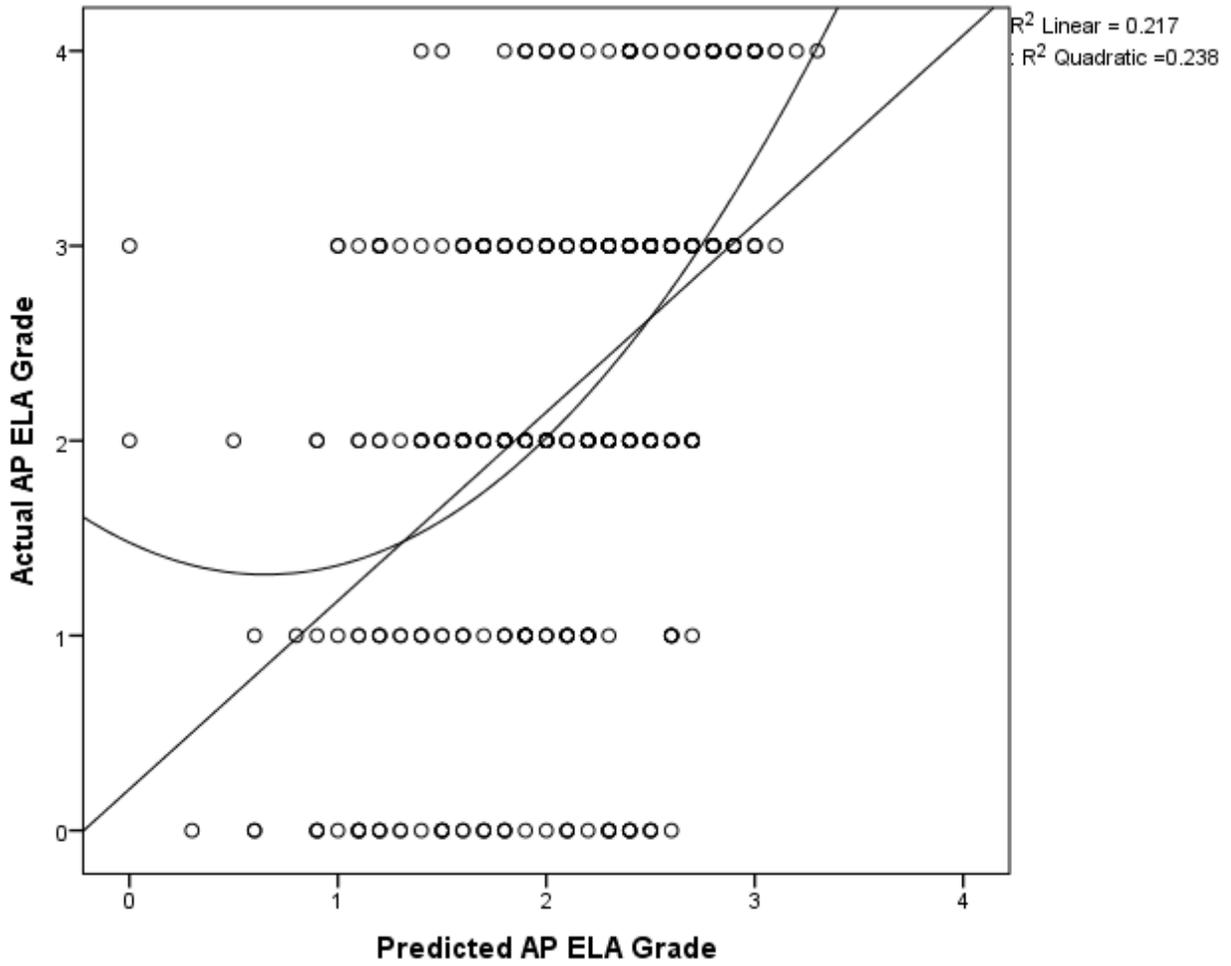


Figure 4: Scatter-plot of predicted fall 2016 ELA AP grades and actual grades

### Accuracy of AP Predictions - Science

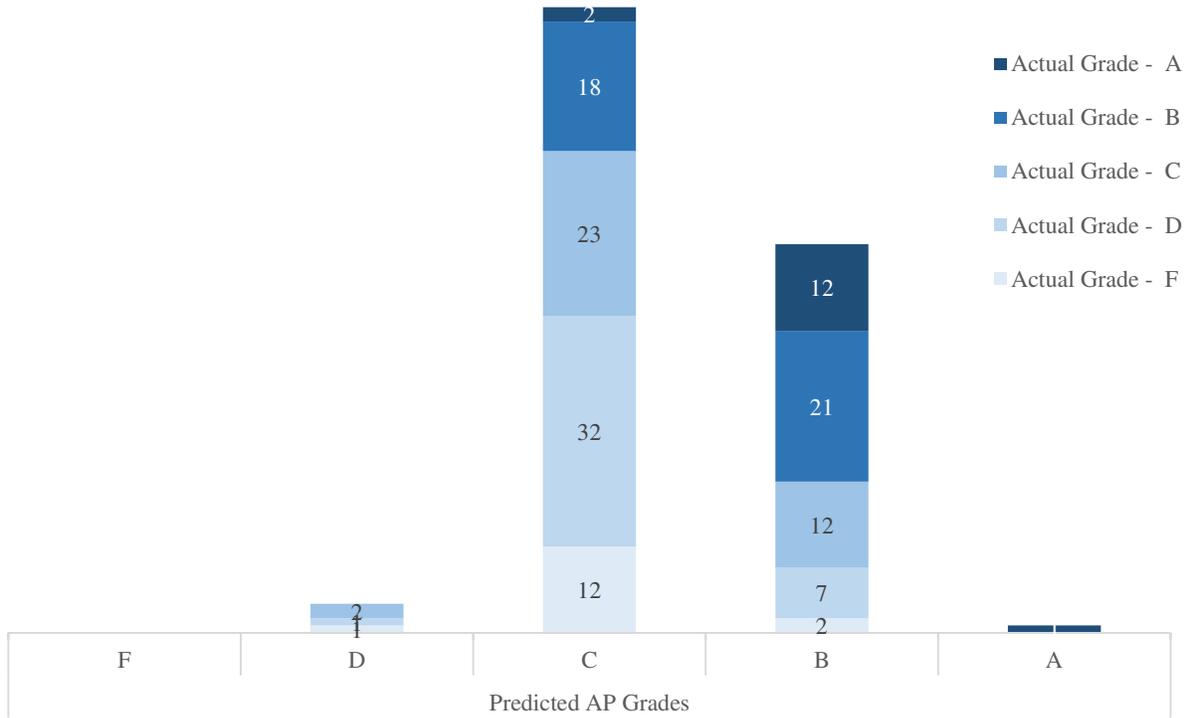


Figure 5: Cross-tabulation of predicted fall 2016 Science AP grades and actual grades

Table 3: Cross-tabulation of predicted fall 2016 Science AP grades and actual grades

		Actual grade				
		F	D	C	B	A
Predicted grade	F	0	0	0	0	0
	D	1	1	2	0	0
	C	12	32	23	18	2
	B	2	7	12	21	12
	A	0	0	0	0	1

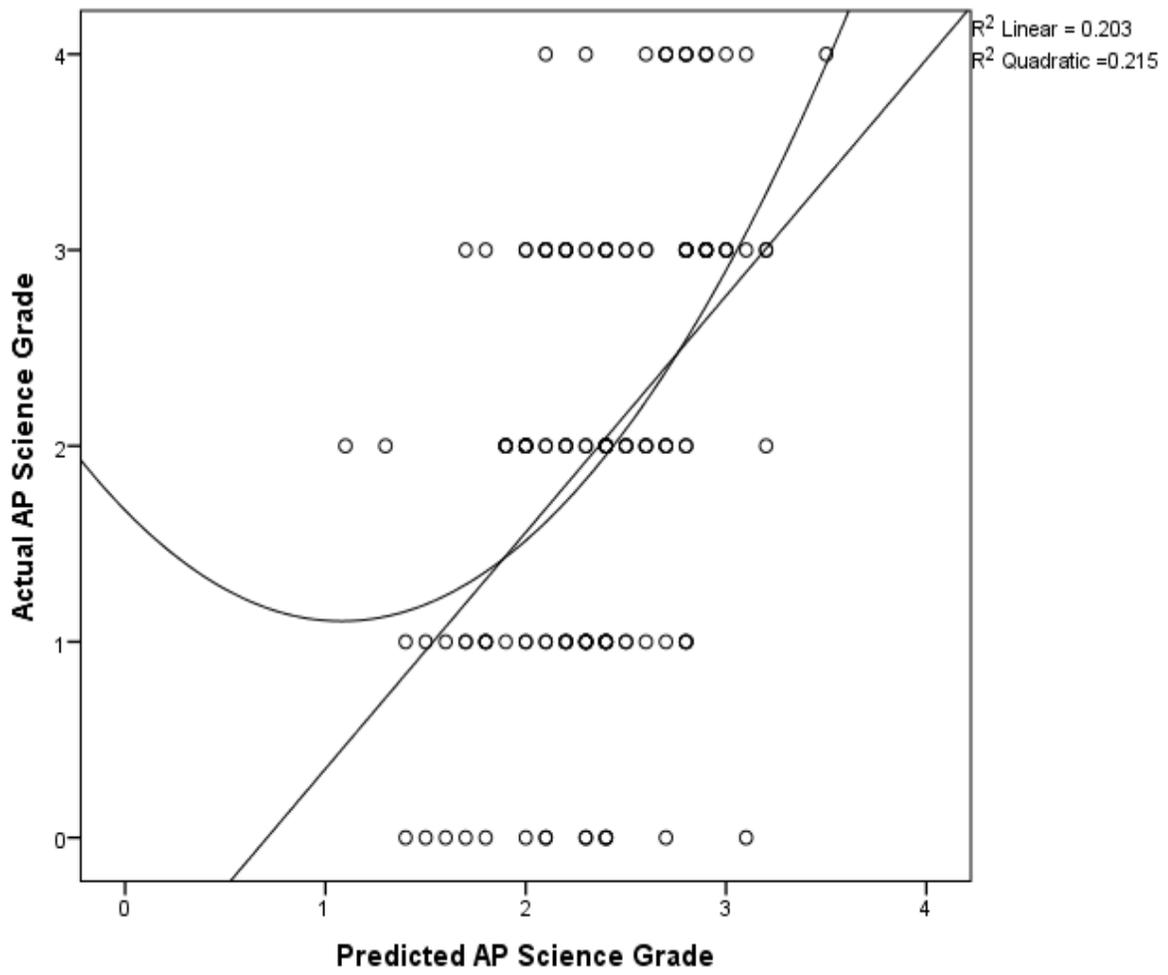


Figure 6: Scatter-plot of predicted fall 2016 ELA AP grades and actual grades

### Accuracy of AP Predictions - Social Studies

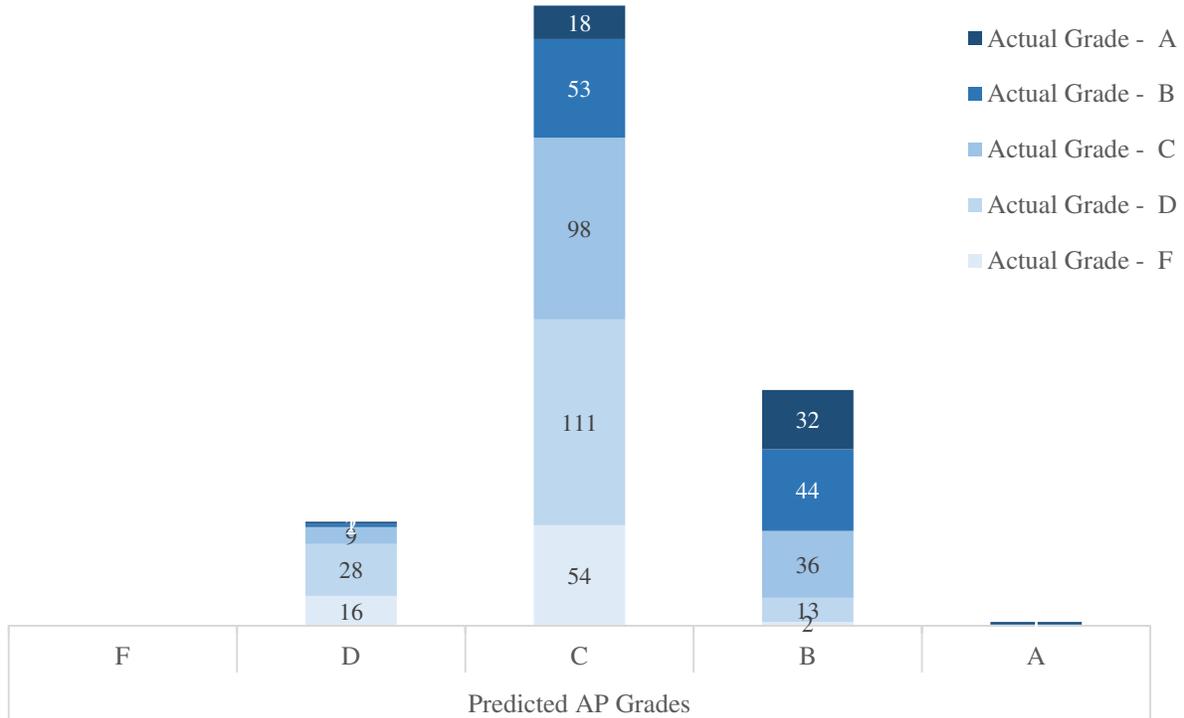


Figure 7: Cross-tabulation of predicted fall 2016 Social Studies AP grades and actual grades

Table 4: Cross-tabulation of predicted fall 2016 Social Studies AP grades and actual grades

		Actual grade				
		F	D	C	B	A
Predicted grade	F	0	0	0	0	0
	D	16	28	9	2	1
	C	54	111	98	53	18
	B	2	13	36	44	32
	A	0	0	0	1	1

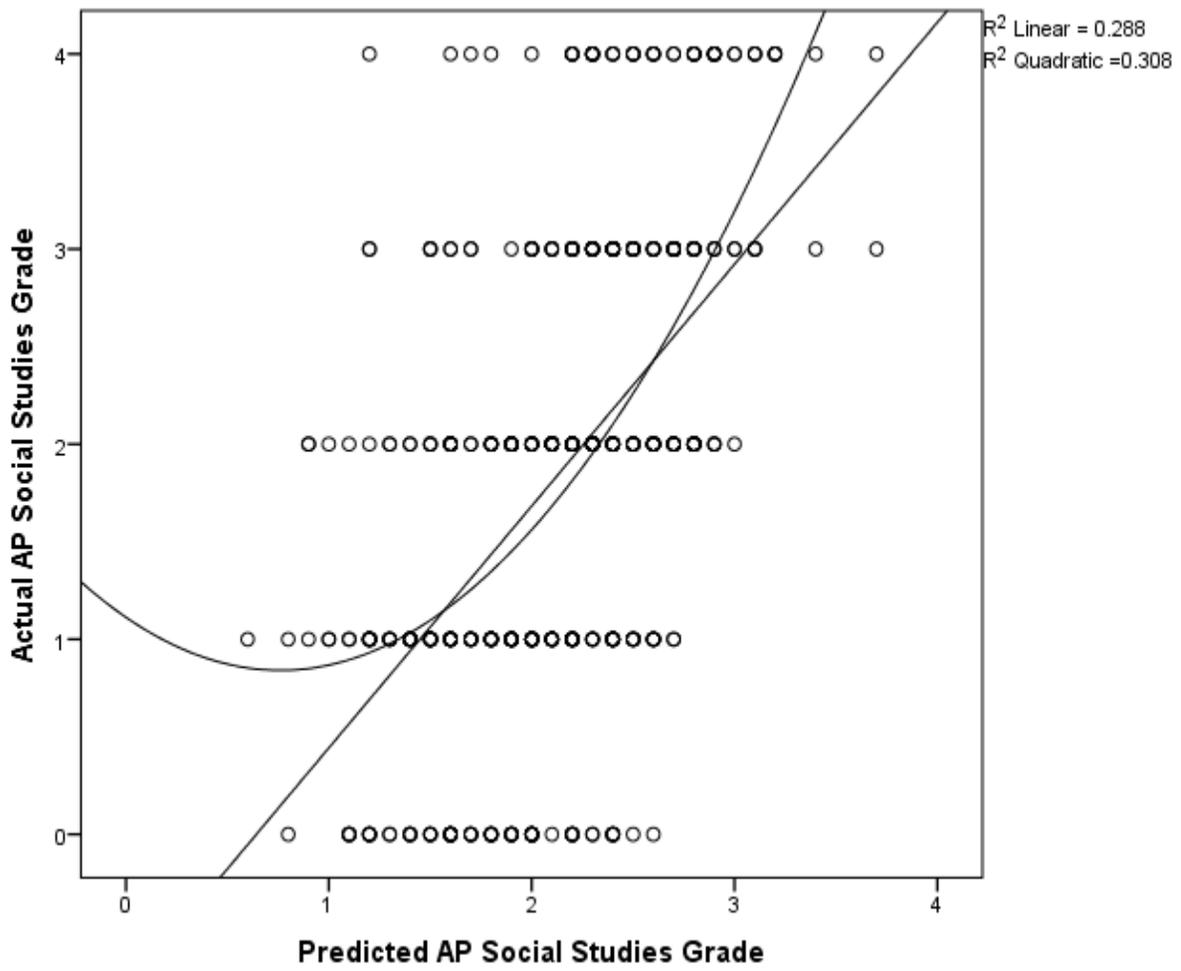


Figure 8: Cross-tabulation of predicted fall 2016 Science AP grades and actual grades

## Appendix B:

### Results of modeling predicting fall 2016 AP Course Grades

#### Math results

Parameter	$\beta$	Std. Error	$t$	Sig.	95% Confidence Interval	
Intercept	0.809	0.225	3.598	0.001	0.362	1.255
Fall 15 Overall grades (Z score)	1.088	0.15	7.242	0	0.789	1.387

$R^2 = .379$  (Adjusted  $R^2 = .372$ )

#### English Language Arts results

Parameter	$\beta$	Std. Error	$t$	Sig.	95% Confidence Interval	
Intercept	1.355	0.078	17.466	0	1.203	1.508
Fall 15 Overall Grades (Z score)	0.763	0.072	10.609	0	0.622	0.904
Spring 15 reading assessment scores (Z score)	0.203	0.061	3.324	0.001	0.083	0.323

$R^2 = .313$  (Adjusted  $R^2 = .310$ )

#### Social Studies results

Parameter	$\beta$	Std. Error	$t$	Sig.	95% Confidence Interval	
Intercept	1.076	0.053	20.456	0	0.973	1.179
Fall 15 Overall Grades (Z score)	0.924	0.046	20.151	0	0.834	1.014

$R^2 = .278$  (Adjusted  $R^2 = .277$ )

#### Science results

Parameter	$\beta$	Std. Error	$t$	Sig.	95% Confidence Interval	
Intercept	0.814	0.123	6.597	0	0.571	1.058
Fall 15 Overall Grades (Z score)	1.053	0.091	11.586	0	0.874	1.233

$R^2 = .388$  (Adjusted  $R^2 = .385$ )



