education analytics

EXECUTIVE SUMMARY

Equity-Aligned Analytics to Support Integrated Early Warning and School Accountability Systems

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This report describes an approach to school accountability systems that addresses equity concerns by combining prospective student-based metrics such as those found in early warning systems with a refined set of school- and district-based retrospective accountability metrics. The major innovation in what we call the Equity-Aligned Analytics System (EAAS) is to provide validated indicators of projected readiness for high school graduation to students, parents, and school staff so they can take action to improve student outcomes, rather than awaiting results from conventional post-hoc accountability measures. These student-level readiness indicators are then rolled up to the school and district levels, and the improvements in readiness between years become part of the school and district accountability system.

Project Theory of Action

The basic theory of action for EAAS is that providing prospective analytics projecting important medium-term outcomes for individual students will catalyze educators, families, students, and other key stakeholders to focus efforts on specific short-range outcomes (i.e. Attendance, Course Enrollment, Test Scores and Grades) that lead to improvements in the medium-range outcomes such as high-school graduation. In parallel, the projections are used to create retrospective school and district accountability measures that show whether these efforts have succeeded in improving students' chances of experiencing positive academic outcomes.

By using the changes in projections from the end of one year to the next as the foundation of a school accountability system, this approach provides an incentive for schools to improve projected readiness as well as tools (detailed projections for individual students) for understanding how to improve readiness to graduate for individual students. The alignment of the prospective and retrospective metrics means that the same actions school staff and other stakeholders take based on indicators of student readiness also directly contribute to improving their school's overall accountability standing. The prospective metrics illustrate potential paths through which retrospective school and district-focused accountability measures can be improved. This approach is equity-oriented because it focuses attention on what each individual student needs to succeed and facilitates explicit assessment of schools' and districts' relative success with underserved and marginalized groups.

The EAAS expands the utility and equity orientation of a typical school accountability system in several substantial ways.

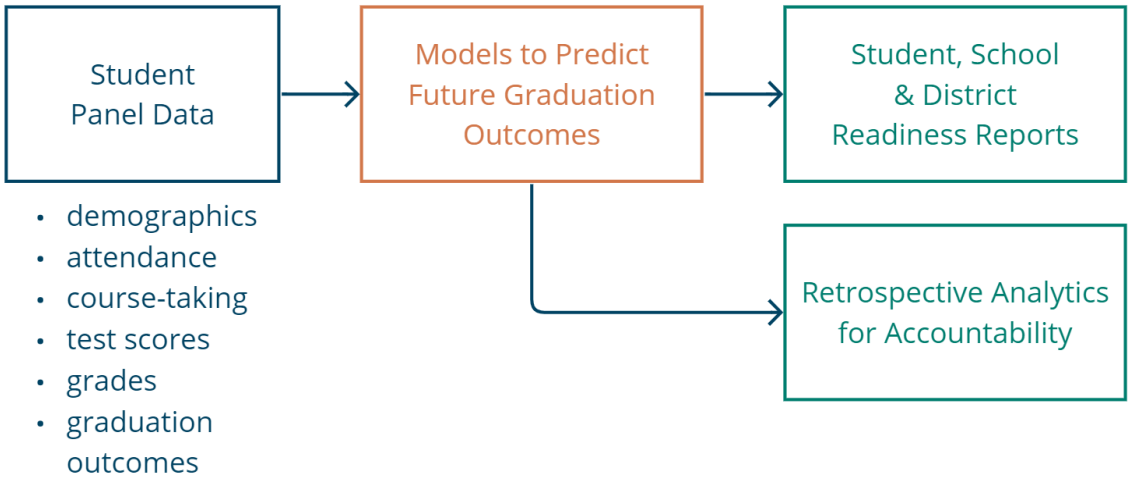
1. EAAS demonstrates the feasibility and appropriateness of expanding accountability metrics beyond test scores and similar aggregate indicators. The expanded set would include a broader set of student indicators, such as attendance, enrollment in challenging courses, and course grades.

2. EAAS integrates early warning and school accountability system features to create a cycle of continual measurement of student progress and support, much like a multi-tiered system of supports. It provides a roadmap to allow educators, students, and parents to maximize opportunities for improvement and to open pathways to future life success. It allows students to compensate for weaknesses in one indicator if they excel in other directions.
3. EAAS makes explicit within- and between-school differences in student outcomes and progress for different demographic groups. Comparative readiness and progress estimates for demographic groups of interest (e.g., economically disadvantaged versus not economically disadvantaged) help schools and the community know whether all students are learning to their full potential within the school environment.

To illustrate how this approach would be implemented and demonstrate its feasibility, EA worked with a large metropolitan district to develop early warning indicators for high school graduation, created student and school-level readiness and progress metrics, and created illustrative reports that can be used as part of ongoing early warning and school accountability systems. The reports focus on student outcomes and readiness in 8th and 9th grades. When fully developed, EAAS would be implemented in all grades.

Methodology for Developing Prospective Metrics

EA developed a comprehensive system for predicting student readiness for graduation by using real life historical student data to feed a set of calibrated models which produce an estimate of each individual student's probability of graduating from high school. These probabilities were then translated into a student readiness index that was also used to create retrospective measures of school performance for accountability. The diagram below illustrates this process.



The methodology used to develop the prospective metrics included the following steps:

- **Identify the medium-term outcomes to predict.** We chose high school graduation as the equity-oriented outcome to predict because graduation is typically the gateway to future opportunities that determine lifelong well-being. This district's system allowed for three levels of the outcome: 1) Did not graduate within four years; 2) regular diploma; 3) Honors diploma.
- **Choose the statistical model.** Because the medium-term outcome predicted is a discrete, multi-valued, and ordered variable, we used an ordered probit model.
- **Choose predictors.** Guided by the literature and our own experience developing predictive models, we chose attendance rate, advanced course enrollment, end-of-course test results, and course grades as predictors. Course grades were adjusted to eliminate any incentive for schools to artificially inflate grades.
- **Calibrate the models.** We used prior years of predictor and graduation data to estimate the weights attached to each predictor.
- **Construct projected readiness metrics for all students in all grades.** Projected readiness values for each student are obtained by multiplying the predictor values by the weights and summing the products. The projected readiness values range from 0 to 100 points. Additionally, projected readiness values are used to construct probabilities for each medium-term outcome, as an alternative and less abstract measure of readiness.
- **Develop metrics that show the student's status on each readiness component.** In addition to overall readiness, we construct metrics for each of the four readiness components: attendance, advanced course enrollment, test scores, and course grades. This reveals the contribution of each component to overall readiness.
- **Evaluate the student and school-level readiness data with an equity lens.** Measure student and school readiness using models that differentiate levels of readiness between and within schools by student demographic status and by school composition by demographic subgroups.

Findings Related to Prospective Metrics

Our research suggests that the prospective metrics are valid and can be used to predict the outcomes of interest.

1. There is substantial differentiation in the total projected readiness values, and considerable variation exists for each readiness component at the student and school levels. This is what is expected at the student level and thereby supports the validity of the metric. At the school level, it shows that the metric can distinguish differences in readiness among schools as is expected of an accountability metric.
2. The projected student and school average readiness scores for each of the four components (attendance, advanced course enrollment, end-of-course test scores, course grades) are correlated, indicating the plausibility of an underlying readiness construct. Yet they are not so highly correlated that one or more indicators are redundant.

3. Together, the four components combine to make a strong predictor of high school graduation.
4. Consistent with prior research, there are differences in student readiness between subgroups defined by economic disadvantaged status and race/ethnicity both within and between schools. However, the effects of school composition on readiness for students in all subgroups is much larger than the differences between subgroups within schools. Equity policies that only focus on differences in early warning risk within schools are likely to fail to adequately address the district challenge.

Methodology for Developing Retrospective Metrics

Retrospective metrics measure the change in readiness for individual students and the average progress made by students at the school and district levels from one school year to the next. Since the retrospective progress metrics are based on the prospective early warning metrics, they show stakeholders whether the actions taken based on the early warning metrics succeeded in increasing student readiness. Progress metrics are the key metrics in school and district accountability systems. The progress model aims to quantify student readiness measured at the end of 9th grade, controlling for student outcomes measured at the end of 8th grade. The methodology used to develop the retrospective metrics involves the following steps:

- **Estimate student readiness separately for each grade: 8th grade and 9th grade.** Separate readiness measures are constructed for both 8th and 9th grades using high school graduation status as the medium-term outcome to be predicted. We assess the robustness of the 8th grade metric by evaluating the extent to which 8th grade variables are predictive of 9th grade readiness. Both approaches yield very similar results.
- **Calculate student progress.** Student progress is given simply by the difference in projected readiness from end of 8th grade to the end of 9th grade. As above, we assess the robustness of the 8th-to-9th grade progress metric by measuring progress as the difference between 9th grade readiness and predicted readiness after controlling for 8th grade student outcomes, which follows the standard approach to measuring growth in valued-added models.
- **Construct student progress by component.** In addition to overall student progress, we also estimate progress for each component as the difference between 9th grade readiness and predicted readiness after controlling for 8th grade student outcomes.
- **Evaluate the student and school-level progress data with an equity lens.** We measure student and school progress using models that distinguish between differences in progress between and within schools by student demographic status and school composition by demographic subgroups.
- **Apply shrinkage.** To improve the accuracy of progress estimates, we apply a reliability adjustment estimation (i.e. statistical shrinkage) to the estimates of school progress. Therefore, all the reported progress estimates are reliability-adjusted metrics.

Findings Related to Retrospective Metrics

1. Student progress accounts for a large share (23%) of end-of-year readiness. While prior readiness is the dominant predictor of current year readiness, there is still substantial scope for improvement, as shown by student progress accounting for 23% of the variance in current year readiness. This implies that student experiences and school supports provided in 9th grade are important determinants of progress and thus end-of-year readiness.
2. There is significant variation across schools in their contributions to overall progress. The share of difference in student progress due to differences across schools is 10.5%. This is larger than what is generally observed in analyses that focus only on math and ELA test scores rather than student readiness based on multiple student outcomes, as is done in this study. This result underscores the importance of measuring school performance on the broadest possible set of student outcomes; it provides further evidence that the school in which a student learns matters.
3. The spread of school progress is much larger for schools with high prior readiness, whereas schools with low prior readiness tend to have levels of progress close to the average for the district. This indicates that among schools with high prior readiness, some experience large increases in readiness while other schools experience large decreases in readiness.
4. There are substantial differences in end-of year and prior year student readiness and progress between economically disadvantaged students and students who are not economically disadvantaged, and between Black, Hispanic, and students from other races/ethnicities. The average readiness values are lower for economically disadvantaged, Black, and Hispanic students compared to other students. The most striking result is that the average student progress was also lower for these three subgroups, indicating that the gaps in readiness have increased on average from 8th grade to 9th grade. Additionally, our findings indicate that differences across schools in student progress for economically disadvantaged students, and Black and Hispanic students are large and therefore deserve to be addressed through strong accountability policies.
5. Across-school comparison reveals that schools with a larger proportion of economically disadvantaged students generally have lower progress than schools with a smaller proportion of economically disadvantaged students. This difference across schools is more than twice as large as the differences due to student status (see #4 above). On the other hand, schools with a larger proportion of Black and Hispanic students tend to show higher progress on average compared to schools with smaller proportion of Black and Hispanic students. These differences have an opposite effect as compared to differences due to race/ethnicity status.

Student, Classroom/School, and District Reporting

Example reports at the student, classroom/school, and district levels were generated to demonstrate how these key stakeholders would engage in the results and how the reports

would interrelate. Unlike most early warning systems, EAAS would include reports summarizing student readiness at the school level based on averaging the readiness metric across students, both in aggregate and by groupings of interest (e.g., racial/ethnic categories, English learners, economically disadvantaged students). This reporting could trigger systematic school-wide action to support students with low readiness to graduate or targeted efforts to support individual students. It could also provide information to school staff on where to focus efforts to improve accountability status. School- and district-wide reporting by group would enable monitoring of progress toward equity goals, based on a set of metrics (graduation readiness) directly related to future life outcomes.

EAAS would also report student progress toward readiness at the school level, which is then the foundation of the proposed school accountability system. Combined, the reports would allow educators and other key stakeholders to reflect on the outcomes and progress of individual students and the school as a whole. As in the early warning reports, progress can be examined across different demographic subgroups.

Stakeholder Reactions

To obtain evidence on whether stakeholders might value the prospective analytics included in EAAS, EA's partners at the Center for Equity for English Learners (CEEL) at Loyola Marymount University conducted a case study of an existing early warning system with the cooperation of two high schools in the Azusa Unified School District in California. Based on interviews, focus groups, and surveys of students, teachers, administrators, and parents, this study found that stakeholders perceived that the early warning system contributed to an increase in student confidence and well-being, self-organization, and communication with teachers, and culminated in an increase in the student readiness and grades in general. These results provide some evidence that the prospective component of the EAAS is valuable and actionable to stakeholders. Input from these stakeholders also suggested that expanding EAAS to incorporate information on planned actions to support students and schools could increase its practical value to educators, families, and students, and thus spur use of the system. This feature was added to the student-level reports.

EAAS Implementation

Implementing a new, equity-aligned accountability system takes time and great consideration. EA presents a menu of required and optional features and outlines the steps of a phased implementation in the full report. The system begins with 8th grade and continues into other grade levels. A highly desirable expansion would be to track post-high school career and technical (CTE) and workforce outcomes. The readiness models would be recalibrated to predict these future outcomes and the reports expanded to show stakeholders how students are being prepared for post-secondary success.

Conclusion and Recommendations

Including predictive analytics such as early warning measures in accountability systems could identify opportunity gaps and root causes of inequities early enough for educators, families, and students to take action, so that more distal outcome gaps in high school graduation rates and even post-secondary well-being can be addressed while schools, students, and caregivers still have a chance to make real change. Basing school accountability metrics on progress in readiness couples the incentives provided by accountability with the opportunity to address individual student needs. The EAAS approach moves beyond simply providing a verdict on school performance to providing an actionable roadmap to improve students' life outcomes.

The research presented here demonstrates that such a system is feasible and produces valid results. The proposal to integrate predictive analytics and early warning systems into the traditional framework of accountability presents a promising avenue for creating an equity-aligned system—a system that is responsive to the schools and communities where the measures are being implemented.

Since this work has succeeded in building the conceptual and methodological foundations for our approach and producing a proof of concept, we recommend that future research build upon the promising findings here to:

- Work with parents and educators to develop tools they and other stakeholders would use to understand and act upon the information provided;
- Explore how the readiness index can be integrated with other accountability measures (e.g., what weight should it carry, does it make other metrics redundant, how does it change rankings of schools);
- Let users "test drive" the prospective metrics and user tools and understand the actions users are likely to take to influence them; and
- Expand the system to use middle-grade and high school indicators to predict workforce/post-secondary education outcomes, providing an even more direct link between schooling and post-secondary well-being.

APPENDIX

The reports below intend to present some examples of how the EAAS metrics can be reported. The results are generated using the 8th and 9th grade student data provided by the large U.S. school district:

- **Table I: Student Early Warning Reports** present examples of school report cards enriched with prospective metrics generated by EAAS. The report provides the student readiness index (overall and by component), the student readiness status and the likelihood of graduation.
- **Table II (a): School Early Warning Report (Part 1)** displays the EAAS prospective metrics for each student in school as well as school level metrics such as school average readiness index, proportion of students across different readiness levels, and the school readiness level.
- **Table II (b): School Early Warning Report (Part 2)** displays the school aggregate readiness metrics across different demographic groups.
- **Table III: End-of-Year School Accountability Report on Readiness** is focused on accountability results. It displays school level retrospective metrics such as student average progress, school performance rating , and school percentiles on progress. The report shows these metrics for all students and across different demographic groups, making it possible to identify and compare the progress for each demographic group in school.

I.

Student report card

Metrics generated by the prospective analytics model

Projected readiness by components:
1. Attendance
2. Advanced Courses
3. Test Scores
4. Course Grades

Student Early Warning Reports

Four Student Examples

	1 High Readiness		2 Medium Readiness		3 Low Readiness		4 Very Low Readiness	
	Outcome	**Readiness**	**Outcome**	**Readiness**	**Outcome**	**Readiness**	**Outcome**	**Readiness**
Constant		1		1		1		1
Attendance	99	**12**	92	**7**	88	**5**	78	**0**
Adv. Courses		**10**		**10**		**0**		**0**
Math	Yes		Yes		No		No	
Science	Yes		Yes		No		No	
Test Scores		**24**		**16**		**0**		**0**
Geometry	85							
Chemistry	92							
Biology			67					
Algebra 1			78		45		40	
Course Grades		**44**		**34**		**23**		**14**
Math	A		A		D		F	
Science	A		B		C		D	
English	B		C		C		C	
Social Studies	A		B		B		D	
Total Readiness		**91**		**68**		**29**		**15**
Readiness Status	R>75	Q4: High	50<R<75	Q3: Medium	25<R<50	Q2: Low	R<25	Q1: Very Low
Post High School Probabilities								
Graduate: non-honors diploma or above		100%		100%		69%		34%
Graduate: honors diploma		88%		35%		0%		0%

Projected Overall Readiness

Probabilities of high school graduation as an alternative measure to projected readiness

Example:
It is interesting to contrast students with low and very low readiness, with total readiness of 29 and 15 points, respectively. The probability of graduating from high school for the low readiness student is twice as large (69%) as the probability for the very low readiness student (34%). The major difference is in course grades as indicated by the corresponding component of projected readiness. If we look more closely, the student report card shows that the very low readiness student failed in the math course.

II (a).

School Early Warning Report, Part 1

School A: High Readiness School

Panel 1: Metrics by Student

	Readiness (R)		Graduation Probabilities	
Student ID	**Readiness Status**	**Total Index**	**Non-honors +**	**Honors**
1	Q4: Very High	91	100%	88%
2	Q3: Medium	68	100%	35%
3	Q2: Low	29	69%	0%
4	Q1: Very Low	15	34%	0%
...	*Student list abbreviated in this table.*			

Information on **overall readiness** for **each student** in the school (same information as in Report I). An interactive software would additionally show the readiness for each component.

Panel 2: Average School Statistics

	Readiness (R)	Graduation Proportions	
School Size	**School Average Index**	**Non-honors +**	**Honors**
1151	83	99%	70%

Summary of school level outcomes: **School Average Index** (the average of readiness projections across all students in school) and the corresponding average graduation rate.

Panel 3: Proportion of Students at Readiness Levels

School Readiness Level	**Q1: Very Low Readiness**	**Q2: Low Readiness**	**Q3: Medium Readiness**	**Q4: Very High Readiness**
S5: Very Low	1%	2%	19%	79%

The first column reports the overall school **readiness level**. The remaining columns report the distribution of readiness across all students in school; the proportion of students at each of the **four readiness levels** (Q1 to Q4).

Student Readiness Levels (Q1 to Q4):
Q1: Very Low: Readiness Index (R) < 25
Q2: Low: 25 < R < 50
Q3: Medium: 50 < R < 75
Q4: Very High: R > 75

The thresholds used to assign students to **readiness status levels** are values that should be set by the schools, districts, or states since they are intended to be trigger action to support students with low readiness. For simplicity, we selected **threshold values** of 25, 50, and 75 on the 0-100 scale.

School Readiness Levels (S1 to S5):
S1: Very Low: Q1 proportion: 27%-55%
S2: Low: Q1 proportion: 18%-26%
S3: Medium: Q1 proportion: 10%-17%
S4: High: Q1 proportion: 3%-9%
S5: Very High: Q1 proportion: 0%-2%

In this report we have defined school readiness levels based on the proportion of students at student readiness level Q1 (R <= 25). We set the threshold values for **five school readiness levels**, designated S1 to S5.

II (b).

School Readiness Index: **overall** and by **demographic groups**

Early Warning Report, Part 2						
School A: High Readiness School						
Panel 4: Readiness by Demographic Groups						
					Proportion of Students	
Group	**Number of Students**	**Group Proportion**	**Readiness Status**	**Average Readiness**	**Q1: Very Low Readiness**	**Q2:Low Readiness**
All Students	1151	100.0%	S5: Very High	83.0	1%	2%
Economically Disadvantaged:						
No	771	67.0%	S5: Very High	83.0	0%	2%
Yes	380	33.0%	S5: Very High	82.9	1%	2%
Race/Ethnicity:						
Black	76	6.6%	S5: Very High	78.0	1%	4%
Hispanic	73	6.3%	S5: Very High	77.6	1%	7%
Other	1002	87.1%	S5: Very High	83.7	0%	1%

Overall and **demographic group** **readiness statuses** as measured by the proportion of students in Q1 – Very Low Readiness Level

Differences in average readiness index across various racial/ethnic groups

III.

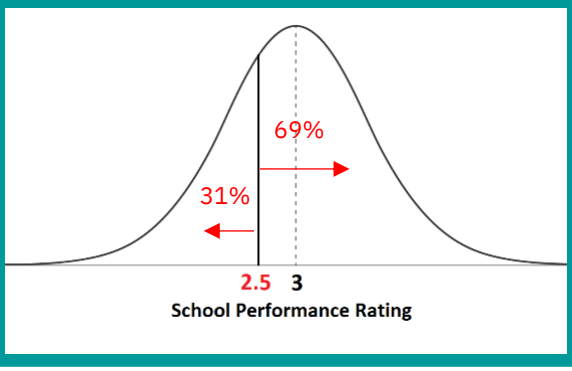
School Progress Metric: Overall and by Demographic Subgroups

End-of-Year School Accountability Report on Readiness								
High School Year 1 (9th Grade)								
Comparability Control Variables: 8th Grade								
School A: High Readiness School								
			Prior Readiness and Progress			**Performance**		
Group variable	**Size**	**Sub-Group %**	**Prior Readiness**	**District Progress Average**	**School Progress**	**Rating Detail**	**Performance Rating**	**School Percentile**
All Students	1151	100.0%	82.98	0.00	-0.03	2.99	P3: Med	50%
Economically Disadvantaged:								
No	771	67.0%	82.87	0.82	0.30	3.07	P3: Med	53%
Yes	380	33.0%	83.21	-0.90	-0.82	2.81	P3: Med	43%
Race/Ethnicity:								
Other	1002	87.1%	83.35	1.59	0.35	3.08	P3: Med	53%
Black	76	6.6%	80.83	-0.50	-2.19	2.50	P2: Low	31%
Hispanic	73	6.3%	80.23	-1.14	-2.74	2.37	P2: Low	26%

Comparison with district

The Standardized School Performance Rating is equivalent to the school progress metric but modified so that the metric can be reported on the same performance scale for all grades and is easy to interpret. The metric is transformed to have mean 3 and standard deviation 1.

E.g. School A rating detail for the Black demographic subgroup is 2.5, which is below the district mean of 3. Assuming progress estimates are approximately normally distributed, growth of Black students in School A is at the 31st percentile, meaning 31% of black students in the district have lower growth but 69% have higher growth.



This is a categorical performance level, where **Rating Detail** is rounded to the nearest integer. This enables the classification of schools by five performance levels:

P1: Very Low (0-1)
P2: Low (2)
P3: Medium (3)
P4 High (4)
P5: Very High (5-6)