Encouraging Participation in Rigorous Courses

Rationale, Methods and Results

Background and Rationale

Students who take rigorous courses in high school can benefit in many ways. They can:

- earn college credit while in high school;
- potentially skip introductory courses;
- save money on postsecondary tuition;
- learn exciting subjects in greater depth; and
- set themselves apart when they pursue college or career opportunities.

From 2012-13 to 2019-20, the Commissioner of Education sent letters directly to students in 10th and 11th grade who had been identified as having the potential to succeed in rigorous courses. The criteria for identification were PSAT scores, and the list was generated using the College Board's AP Potential tool.[1] In the 2020-21 academic year, the Connecticut State Department of Education (CSDE) analyzed enrollment and course performance data for rigorous courses – including dual enrollment (DE) classes offered by colleges and universities, Advanced Placement (AP®) courses, and the International Baccalaureate (IB) program – and extended its methodology to include Smarter Balanced Assessment Consortium mathematics and English language arts (ELA) assessment results to identify students for this mailing.

The CSDE analyses confirmed that students who do well on Smarter Balanced assessments during middle school generally perform well in one or more rigorous courses in high school. Looking beyond the AP Potential tool enabled the CSDE to identify an additional 15,000 students statewide who may do well in advanced courses. Moreover, this increased the diversity of the recipient list, as more students of color, students from low-income families, English learners, and students enrolled in Alliance Districts were encouraged to participate in rigorous courses.[2] The 2020-21 letters were sent to students in Grades 10 and 11 (as was the case in prior years) and to their parents/guardians in April and May of 2021.

In 2021-22, the CSDE implemented changes to this process based on feedback received in the previous year. Additionally, the CSDE assembled a representative group of principals and school counselors to get their input on the messaging, communication, and timing of the various activities.

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[1] The AP Potential tool identifies students who are likely to score a 3 or higher on a given AP® Exam based on their performance on the PSAT/NMSQT®, PSAT™ 8/9, PSAT™ 10, or SAT®.

[2] The Alliance District program is a unique and targeted investment in Connecticut's lowest-performing districts. Connecticut General Statute Section 10-262u establishes a process for identifying Alliance Districts and allocating increased Education Cost Sharing (ECS) funding to support district strategies to dramatically increase student outcomes and close achievement gaps by pursuing bold and innovative reforms.

The following changes were implemented in 2021-22:

- The letters were sent to students in Grades 9 and 10 (instead of 10 and 11) to allow students more time to plan their course pathway in high school;
- The letters were sent in January to allow time for students and families to plan course selection in advance of initial registration deadlines;
- The list of students receiving these letters was available in EdSight Secure by mid-December, so principals and counselors knew in advance which students were to receive the letters;
- An FAQ and copies of the actual letters being sent were provided by mid-December so district/school staff were prepared to answer any questions from parents and students about the letters; and
- The CSDE hosted an optional informational session for principals and counselors in mid-December to discuss the next steps and answer any questions.

In 2022-23 and beyond, the CSDE will continue to identify students in grades 9 and 10, and notify schools, students, and families well in advance of course registration deadlines.

Methods

Model Development Used Supervised Learning

The methods used for this project involved data preparation and data handling in addition to model training, testing, and comparison before the final model was established. The CSDE created a classification and regression tree (CART, or decision tree) model for this project. This CART model employed supervised learning, which occurs when outcomes are used in the preprocessing of data. This approach is a powerful way to classify a set of observations into groups that are directly observed.

Forecasting a student's likelihood of passing at least one rigorous course based on standardized test scores includes the prediction of a binary outcome from quantitative independent variables. A decision tree is well-suited for solving a classification problem like this, as the CART technique automates data processing and builds an optimal decision tree by finding predictor variables and cut-points that can be used in combination for yes-no questions to best predict classifications. By capturing classification decisions through a series of yes-no questions, the final model is easy to interpret and apply.

Predictors Were Limited to Standardized Test Scores

Since the AP Potential tool only incorporates PSAT and SAT scores in identifying students with the potential to do well on AP exams, the CSDE decided to take a similar approach: The CART model

considered middle school Smarter Balanced ELA and math scores, as well as student performance on the Grade 8 Next Generation Science Standards (NGSS) Assessment as predictors of a student's likelihood of passing at least one rigorous course in high school.[3]

Using Classification Accuracy Measures and Multiple Pathways Helped Improve Model Performance

Classification accuracy measures. A validation dataset was used to test the model, and true-positives (TP), false-positives (FP), false-negatives (FN), and true-negatives (TN) for predicted and true conditions were determined. In those four designations, the true/false indicator identifies whether the predicted classification was correct/incorrect, and the positive/negative indicator denotes the predicted class as passing/not passing at least one rigorous course by the end of junior year. In addition, the accuracy, sensitivity, specificity, and balanced accuracy were considered for the model.

Accuracy Equations. The equations for calculating classification accuracy measures for each model are an essential component in evaluating and comparing models. Since accuracy, sensitivity, specificity, and balanced accuracy are metrics that are commonly used to select between classification models, these classification accuracy measures are explained below.

Accuracy (also known as the overall accuracy rate) represents the proportion of correct predictions among all cases in the validation sample.

$$\text{Accuracy} = (TP + TN) / N \quad (1)$$

Sensitivity (also known as recall or true-positive rate [TPR]) measures the proportion of correct predictions among all observed positive cases in the validation sample.

$$\text{Sensitivity} = TP / (TP + FN) \quad (2)$$

Specificity (also known as true-negative rate [TNR]) measures the proportion of correct predictions among all observed negative cases in the validation sample.

$$\text{Specificity} = TN / (TN + FP) \quad (3)$$

[3] Since advanced course offerings differ from high school to high school, it was deemed appropriate to expand the outcome measure when developing the CART model. Therefore, instead of simply predicting the likelihood of passing at least one rigorous course in high school, the model also looked to identify those students who are likely to reach college and career readiness score thresholds on the SAT Evidence-Based Reading and Writing (ERW) and math sections.

Balanced accuracy is an average of the sensitivity and specificity, and it measures the average accuracy in classifying minority and majority class observations.

$$\text{Balanced Accuracy} = (\text{Sensitivity} + \text{Specificity}) / 2 \quad (4)$$

Dataset

The full dataset consisted of data collected from the population of Connecticut public school students who were enrolled in grade 11 in 2021-22 and had at least one Smarter Balanced score in grade 8. Loosening the restrictions (i.e., not requiring all possible Smarter Balanced ELA and math scores in grades 6 to 8) allowed for the model to be trained and tested using a larger sample and for the impact of including different variable combinations as predictors to be evaluated.

Training and validation datasets. In order to obtain accurate forecasts, the CART model was developed using holdout sample validation, a process in which part of the sample is designated for model training, and the remaining part of the sample is dedicated exclusively to model testing (also known as validation). The large sample size allowed for data splitting to obtain independent training and validation datasets. Stratified random sampling was used to partition the data and preserve the overall class distribution. The training sample contained 80 percent of the records and was used to derive the model. The remaining 20 percent of records comprised the validation dataset that was used to evaluate the classification accuracy of the model.

Analysis and Cut-Points for Rigorous Coursework Potential

Connecticut's Growth Model for the Smarter Balanced Summative Assessments in ELA and Mathematics includes Achievement Level Ranges that are used in achievement and accountability reporting. Since these ranges are well-established, achievement levels rather than scale scores were used as predictors in the CART model. The ELA and math Achievement Level Ranges are presented in Tables 1 and 2, respectively.

Table 1
Smarter Balanced ELA Achievement Level Ranges

Grade	Level 1 (Not Met): LOW (1)	Level 1 (Not Met): HIGH (2)	Level 2 (Approach): LOW (3)	Level 2 (Approach): HIGH (4)	Level 3 (Met): LOW (5)	Level 3 (Met): HIGH (6)	Level 4 (Exceed): LOW (7)	Level 4 (Exceed): HIGH (8)
6	2210-2417	2418-2456	2457-2493	2494-2530	2531-2574	2575-2617	2618-2656	2657+
7	2258-2438	2439-2478	2479-2515	2516-2551	2552-2600	2601-2648	2649-2687	2688+
8	2288-2446	2447-2486	2487-2526	2527-2566	2567-2617	2618-2667	2668-2703	2704+

Table 2
Smarter Balanced Mathematics Achievement Level Ranges

Grade	Level 1 (Not Met): LOW (1)	Level 1 (Not Met): HIGH (2)	Level 2 (Approach): LOW (3)	Level 2 (Approach): HIGH (4)	Level 3 (Met): LOW (5)	Level 3 (Met): HIGH (6)	Level 4 (Exceed): LOW (7)	Level 4 (Exceed): HIGH (8)
6	2235-2434	2435-2472	2473-2512	2513-2551	2552-2580	2581-2609	2610-2639	2640+
7	2250-2438	2439-2483	2484-2525	2526-2566	2567-2600	2601-2634	2635-2664	2665+
8	2265-2456	2457-2503	2504-2544	2545-2585	2586-2619	2620-2652	2653-2685	2686+

Criteria for Rigorous Coursework Potential.[4] A student who meets any of the following criteria is identified as having shown the potential to complete rigorous coursework in high school:

- "Level 4: Exceeded" on the Grade 8 NGSS Assessment or any Smarter Balanced assessment (ELA or math) in Grade 6, 7, or 8;
- "6-High Level 3: Met" on Smarter Balanced ELA in Grade 8;
- "Level 3: Met" on Smarter Balanced math in Grade 8;
- "Level 3: Met" on both Smarter Balanced ELA and math in Grade 6 or 7 and "4-High Level 2: Approaching" on both Smarter Balanced ELA and math in Grade 8.

RESULTS

The set of criteria was applied to the most recent Grade 11 data in order to see how well the decision rules predicted actual student classifications. This sample had 33,293 records, 62.5 percent of which met the criteria for rigorous coursework potential.

Table 3 presents the accuracy measures for the final model. The accuracy was 0.76, which means that 76 percent of all cases in the final validation sample were predicted correctly. The sensitivity or true-positive rate (TPR) was 0.73 for Grade 9 and 0.74 for Grade 10, which means that over 73 percent of all

[4] Since statewide summative assessments were not administered in 2019-20 due to the pandemic, Grade 10 students in 2022-23 generally have Smarter Balanced scores for grades 6 and 8, while Grade 9 students have scores for grades 7 and 8.

observed positive cases in the validation sample were predicted correctly. The specificity or true-negative rate was 0.80. In other words, 80 percent of all observed negative cases (i.e., those students who did not pass at least one rigorous course and did not meet the SAT threshold for college and career readiness) in the validation sample were predicted correctly. Finally, the balanced accuracy – which is an average of the sensitivity and specificity – shows that the average accuracy in classifying positive and negative cases was 77 percent.

Table 3
Accuracy Measures for Final Model

Metric	Grade 9	Grade 10
Accuracy	0.76	0.76
True Positive Rate (Sensitivity)	0.73	0.74
True Negative Rate (Specificity)	0.80	0.80
Balanced Accuracy	0.77	0.77

Discussion

With all accuracy measures between seventy-three and eighty percent and a revised methodology that resulted in thousands of additional students being encouraged to enroll in rigorous courses, Connecticut is well-positioned to help more high school students realize their true potential. The strong relationship between middle school Smarter Balanced and NGSS Assessment scores and high school outcomes (including performance in advanced high school courses and SAT scores) shows that there are plenty of data points prior to the PSAT that can help identify student potential.

Implications of Results

When the decision rules were applied to the students enrolled in grades 9 and 10 as of December 9, 2022, nearly 32,000 students were identified as having the potential to succeed in rigorous courses. In the end, 15,636 9th graders (36.2% of 43,159 students) and 16,169 10th graders (38.3% of 42,239 students) were selected to receive letters encouraging them to enroll in rigorous courses. Our analyses have confirmed that the middle school Smarter Balanced and NGSS Assessment scores are highly predictive of subsequent academic milestones, so we are confident that these students can succeed in one or more advanced courses.

Conclusion

Students who take rigorous courses in high school can benefit in many ways. By expanding its methodology for identifying students who have shown the potential to succeed in rigorous courses, the CSDE will continue to identify a more diverse and larger number of students who can receive the benefits of taking dual enrollment (DE), Advanced Placement (AP®), and International Baccalaureate (IB) program courses. The CSDE aims to increase access to rigorous coursework and to highlight students who may have been missed by other means. These efforts to encourage participation in rigorous courses are meant to supplement the course selection process and enhance the dialog between families and high school counselors.

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