How to Compute School and Classroom Effective Indices: The Value-Added Model Implemented in Dallas Independent School District

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The basic building blocks of School and Classroom Effective Indices are students' Pre-Test and Post-Test scores and student and school demographic variables. Using this information School and Classroom Effective Indices are calculated in a three stage process.

<u>Stage One – Fairness Stage</u>: In this stage students who are not continuously enrolled are filtered out and students' Pre-Test scores and Post-Test scores are regressed against student level characteristics to remove any bias in test scores. For CEIs based on yearlong courses, a student must be enrolled at that school for 123 days and not be absent for more than 20 days. For fall semester CEIs, a student must be enrolled at that school for 68 days and not be absent for more than 10 days. For spring semester CEIs, a student must be enrolled at that school for 55 days and not be absent for more than 10 days. This constraint of continuous enrollment was implemented to ensure that teachers had sufficient days of instruction with that student to make an impact on his or her education. The other part of the fairness stage is the regressing out of student level covariates from both the Pre-Test Scores and Post-Test Scores of all students. Student level covariates that are regressed out are:

X_{1ij} = Af. Am. English Proficient Status (1 if Af. Am. and English Proficient, 0 otherwise)
X_{2ij} = Hispanic English Proficient Status (1 if Hispanic and English Proficient, 0 otherwise)
X_{3ij} = Limited English Proficient Status (1 if LEP, 0 otherwise)
X_{4ij} = Gender (1 if Male, 0 if Female)
X_{5ij} = Free or Reduced Lunch Status (1 if on Free or Reduced Lunch, 0 Otherwise)

X_{6ij} = Block Level Average Family Income
X_{7ij} = Block Level Average Family Education
X_{8ij} = Block Level Average Family Poverty Level
X_{kij} = Indicates variable *k* for the i^{th} student in school *j*.

The equation for the fairness regression is:

$$\begin{aligned} Y_{ij} = {} & \Lambda_0 + \Lambda_1 X_{1ij} + \Lambda_2 X_{2ij} + \Lambda_3 X_{3ij} + \Lambda_4 X_{4ij} + \Lambda_5 X_{5ij} + \Lambda_6 X_{6ij} + \Lambda_7 X_{7ij} + \Lambda_8 X_{81ij} \\ & + \Lambda_9 X_{1ij} X_{4ij} + \Lambda_{10} X_{2ij} X_{4ij} + \Lambda_{11} X_{3ij} X_{4ij} + \Lambda_{12} X_{1ij} X_{5ij} + \Lambda_{13} X_{2ij} X_{5ij} + \Lambda_{14} X_{3ij} X_{5ij} \\ & + \Lambda_{15} X_{4ij} X_{5ij} + \Lambda_{16} X_{1ij} X_{4ij} X_{5ij} + \Lambda_{17} X_{2ij} X_{4ij} X_{5ij} + \Lambda_{18} X_{3ij} X_{4ij} X_{5ij} + r_{ij} \end{aligned}$$

where the interaction terms are:

Λ_9 = Af. Am. x Gender interaction
Λ_{10} = Hispanic x Gender interaction
Λ_{11} = LEP x Gender interaction
Λ_{12} = Af. Am. x Free/Reduced Lunch interaction
Λ_{13} = Hispanic x Free/Reduced Lunch interaction
Λ_{14} = LEP x Free/Reduced Lunch interaction
Λ_{15} = Gender x Free/Reduced Lunch interaction
Λ_{16} = Af. Am. x Gender interaction x Free/Reduced Lunch interaction
Λ_{17} = Hispanic x Gender interaction x Free/Reduced Lunch interaction
Λ_{18} = LEP x Gender interaction x Free/Reduced Lunch interaction

In the equation above, Y_{ij} is either the students' Pre-Test or Post-Test Score. The regression is carried out for each type of test score available by grade. For example, for Grade 3 the above process is repeated for each Pre-Score and Post-Score for English and Spanish Norm Referenced Language Arts and Mathematics and English and Spanish *TAKS* Reading, Writing and Mathematics. For each regression, the residuals, $\hat{r}_{ij}$s are calculated and will be called the Fairness Adjusted Pre-Scores and Post-Scores. From here onwards these Fairness Adjusted Pre-Scores (the student's previous year's test scores in each subject) and Fairness Adjusted Post-Scores (the student's current year's test scores in each subject) are used for all computations. The next task is to determine which Fairness Adjusted Pre-Score or Pre-Scores are used to predict each Fairness Adjusted Post-Score. This is accomplished by repeatedly carrying out regression with all possible combinations of predictors and statistically choosing which Pre-Score or Pre-Scores are the best possible predictor or predictors. For example, to predicting the outcome of English *TAKS* Mathematics in Grade 3, it could be determined that the previous year's Norm Referenced Mathematics and *TAKS* Mathematics combined would be the best predictors.

Stage Two – HLM Stage: The second stage is the calculation of students' value-added gains using residuals from a hierarchical linear regression model. Stage one has already determined which Fairness Adjusted Pre-Score or Pre-Scores ($\mathrm{PRE\_1_{ij}}$ or/and $\mathrm{PRE\_2_{ij}}$) are to be used in predicting the Fairness Adjusted Post-Score ($\mathrm{POST_{ij}}$). These selected students variables and school level variables are then used to model value-added student gains. The following Hierarchical Linear Model (HLM) was developed to model the students' scores while controlling for selected school level variables.

$$\mathrm{POST_{ij}} = B_{0\mathrm{j}} + B_{1\mathrm{j}}\mathrm{PRE\_1_{ij}} + B_{2\mathrm{j}}\mathrm{PRE\_2_{ij}} + \delta_{\mathrm{ij}},$$

where $POST_{ij}$ is the current years Fairness Adjusted Post-Score and PRE_1_{ij} and PRE_2_{ij} are the Fairness Adjusted Pre-Scores for student i in school j. At the second level of the Hierarchical Linear Model, each B_{0j}, B_{1j}, and B_{2j} is predicted using the school level covariates as follows:

$$B_{0\mathrm{j}} = \Gamma_{00} + \sum_{k=1}^{10} \Gamma_{0\mathrm{k}} \mathrm{W_{kj}} + u_{0\mathrm{j}},$$

$$B_{1\mathrm{j}} = \Gamma_{10} + \sum_{k=1}^{10} \Gamma_{1\mathrm{k}} \mathrm{W_{kj}},$$

$$B_{2j} = \Gamma_{20} + \sum_{k=1}^{10} \Gamma_{2k} W_{kj},$$

where for the j^{th} school,

W_{1j} = School Mobility,
W_{2j} = School Over crowdedness,
W_{3j} = School Average Family Education,
W_{4j} = School Average Family Income,
W_{5j} = School Average Family Poverty Index,
W_{6j} = School Percentage on Free or Reduced Lunch,
W_{7j} = School Percentage Minority,
W_{8j} = School Percentage African American,
W_{9j} = School Percentage Hispanic,
W_{10j} = School Percentage Limited English Proficient.

The Hierarchical Linear Model identifies the best linear model where the combined variance at level one, the student level and level two, the school level, are minimized. This is achieved by modeling each student's gain within each school j. Thus, the model yields a linear regression line for each school.

Computing School Effectiveness Indices

u_{0j}s measure the variation in the intercept of the school level regression line to the overall regression line for the district. The School Effectiveness Index for school j is the reliability adjusted estimate of u_{0j}, $\hat{u}^*_{0j}$. The reliability adjustment is a shrinkage adjustment where $\hat{u}_{0j}$ is shrunk towards the overall district mean if the reliability of this estimate is low.

Stage Three – Summative Stage: In this stage, value-added gains are computed for each student. In the calculation of the value-added gains, the residuals are calculated from the district level regression line to arrive at gains that are not school specific. For example, if Post Score is Grade 3 Fairness Adjusted *TAKS* English Score and *PRE_1* and *PRE_2* are Fairness Adjusted *TAKS* English Pre-Score and Fairness Adjusted Norm References English Pre-Score, the i^{th} student in schools j has a value-added gain for *TAKS* English of

$$\hat{\delta}_{ij} = \mathrm{POST}_{ij} - (\hat{\Gamma}_{00} + \hat{\Gamma}_{10}\mathrm{PRE\_1}_{ij} + \hat{\Gamma}_{20}\mathrm{PRE\_2}_{ij}) .$$

When all HLM regressions are carried out for all courses and tests for all grades, each student will have a residualized gain, $\hat{\delta}$, for each test taken. For example, a Grade 3 student will have residualized gains for Norm Referenced Reading and Mathematics and *TAKS* Reading and Mathematics. A high school student will have residualized gains for each *ACP* (Assessment of Course Performance) test taken and if in Grade 9 for Norm Referenced Language Arts and Mathematics and if in Grade 10 for *TAKS* Language Arts, Mathematics, and Writing.

Computing Classroom Effectiveness Indices

Value-added gains from Stage Three are appropriately grouped and aggregated with a reliability adjustment to arrive at Classroom Effectiveness Indices. For each Elementary and Middle School, student's gains are identified as to which grade, type of test, and subject it belongs to. For High School students, separate grades are not considered in the aggregation process. The gains are then assigned to the Course and Section Number that the student was enrolled in.

The Section Level Classroom Effectiveness Index for a teacher is the reliability adjusted mean value-added gain of students in that section for that grade, test-type, and course in the required subject. The reliability adjustment is a shrinkage adjustment that moves a teacher's CEI towards the overall mean of the residuals if the within teacher variance is high compared to the overall variance of the value-added gains.

To compute the reliability-adjusted CEIs, first compute the overall mean and variance of the value-added gain scores as μ_δ and σ_δ^2. Then compute the unadjusted CEI for a teacher by aggregating the N value-added gain scores as follows:

$$CEI_t = \frac{1}{N_t}\sum_{S=1}^{N_t} \hat{\delta}_{\mathrm{S}} .$$

Compute the variance of the value-added gain scores for teacher *t* as σ_t. The reliability-adjusted CEI for teacher *t* is

$$CEI_t^R = \mu_\delta + (CEI_t - \mu_\delta)\frac{\sigma_\delta^2}{\left[\sigma_\delta^2 + \sigma_t^2 / N_t\right]}$$

where $\frac{\sigma_\delta}{\left[\sigma_\delta + \sigma_t / N_t\right]}$ is the reliability of the CEI for teacher *t*. If the ratio $\frac{\sigma_t}{N_t}$ is very small compared to σ_δ, the reliability will tend to one and the teacher's reliability adjusted CEI will be very close to the unadjusted CEI. If the reliability is low, the reliability adjusted CEI will be shrunk towards the overall mean of the value-added gain scores σ_δ. The reliability-adjusted CEIs are all standardized to a mean of 50 and standard deviation of 10 in the final presentations.

In addition to section level CEIs, a course level CEIs is also calculated. This is the mean CEI for the teacher for that grade, test type, subject, and course irrespective of section. The final step in the CEI computation is the standardization of all CEIs within the Grade, Test Type, and Subject group to a mean of 50 and standard deviation of 10.

If multiple tests were administered at that grade level or course, this sequence of assignments results in teachers having more than one CEI for each section taught. For example, a middle school teacher teaching two sections of Grade 8 Algebra I and two sections of Grade 8 Algebra I Pre-Honors will receive eight section level CEIs, four for *TAKS* Mathematics and four for Norm Referenced Mathematics. This teacher will also receive four course level CEIs for the two courses, Algebra I and Algebra I Pre-Honors, two for *TAKS* Mathematics and two for Norm Referenced Mathematics. Self contained elementary school teachers will receive Norm Referenced and *TAKS* CEIs for mathematics and reading, and if teaching grade four, a CEI for TAKS writing. Since most self-contained elementary teachers teach only one classroom of students, their section level CEI will be the same as their course level CEI.

Grouping Variables for Each Residualized Gain

Grade	**Test Type**	**Subject**	**Course/Section**
1 - 9	Norm Referenced (*ITBS*, *Logramos*, *RPTE*, *WM*)	Reading &Math	Course Number and Section the student is enrolled in that resulted in the test being given in that subject
3 - 11	*TAKS* (First administration only)	Reading & Math	
4, 7	*TAKS*	Writing	
5, 10, 11	*TAKS*	Science	
8, 10, 11	*TAKS*	Social Studies	
7-12	Assessment of Course Performance	LA & Math	
7-12	Assessment of Course Performance	Social Studies	
7-12	Assessment of Course Performance	Science	
7-12	Assessment of Course Performance	Foreign Language	
7-12	Assessment of Course Performance	Technology	

- Only the February administration of the Exit TAKS for first time 11th grade students is included.

Teachers receive their CEI reports within the first four weeks of the next academic year and are required to make use of the CEIs in discussions with the administrators in their Instructional Improvement Plans (IIP). The CEI reports not only give the teachers' Effectiveness Indices, but also growth for each student included in the CEI. The growth measure indicates the students' adjusted value-added achievement attained during the tenure of the teacher. These adjusted value-added achievements of the students in the classroom are averaged to obtain the teacher's CEI.

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