Student Growth Percentile Modeling

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Introduction

This paper introduced student growth percentiles used to calculate the students' growth curve for both the same scale (MAP vs. MAP) and disparate scale (MAP vs. SBA-ELA) using the quantile regression analysis techniques. The student growth percentiles and the associated methodology as a means of fulfilling recently increasing needs of directing the Seattle Public Schools to develop and implement a growth model for elementary early literacy assessment. Given these guidelines, the purpose of developing these percentiles is to provide educational stakeholders with a rigorous means by which to understand student consecutive progress given the longitudinal data currently available.

The student's Growth percentile uses longitudinal assessment data to monitor the progress of students and schools. The Student Growth Percentile (SGP) model describes how well a student performed relative to peers with similar score histories. In the current report, SGP is provided for a normative measure of growth describing the growth of Grade 2 students on MAP Reading of three years combined (2016-2018), and Grade 3 students growth on SBA- ELA from the prior year MAP reading score of three years combined (2015-2017). The students SGPs can be used to address important questions as below:

1. How much growth are the Grade 2 students from their reading for MAP score from Grade 1 compare to other peers on the same historical record in Seattle Public Schools?
2. How much growth are the Grade 3 students from their prior reading for MAP score to SBA English Language Art (ELA) score compare to other peers on the same historical record in Seattle Public Schools?

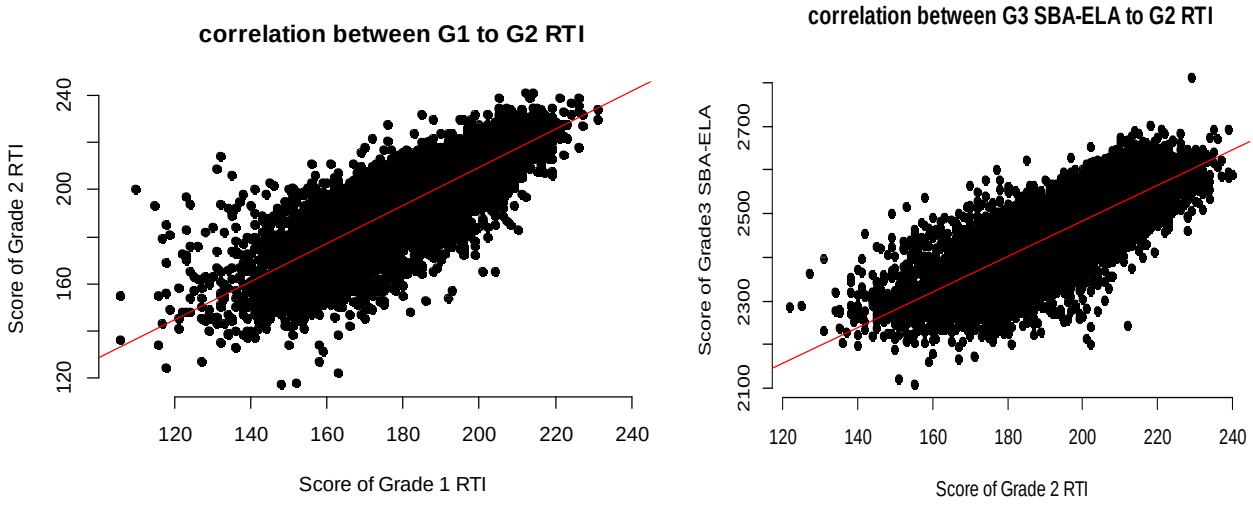
Data Resource

Resources for SGPs are provided for the Measures of Academic Progress (MAP) assessment Reading. MAP Growth is used to measure their reading growth from Grade 1 to Grade 2. The RIT score ranges from 0 to 300. In total, 11209 Grade 2 students combined with three years (2016-2018) with their prior MAP score (2015-2017) were included in the study. Their results are used to estimate the MAP growth curve with quantile regression. On the other side, in total, 11133 Grade 3 students of three years combined (2016-2018) with their prior MAP-reading score (2015-2017) are included in the study. SBA English language Art (ELA) score is the state standardized score for English Language\Literacy Arts ranges from 0 – 2795 with 4 scales of proficiency scale: Not Met Standard, Nearly Met Standard, Met Standard, Exceed Standard.

SGP Look-up Table

On appendices, the tables provide the SGP value (ranging from 1 to 99) associated with each combination of current-year test scores and prior-year test scores. For example, in Appendix A, suppose a student scored 171 on the Grade 2 MAP reading test and 188 on the Grade 1 MAP reading test one year later. His/her SGP would be 56 (as shown in the table below). This means the students rank 59 percentiles higher than his/her peers who obtain the same prior-year test score of 171.

Correlation of G1-G2 RIT, G2 RTI-G3 SBA-ELA



The results indicated the correlation between the Grade 3 SBA-ELA and Grade 2 MAP-reading scores are statistically significantly correlated, $R^2 = 0.67$, $p < .001$. 67% variances of the Grade 2 RIT score can be explained by their prior Grade 1 RIT score.

There is also statistically significant correlation between the Grade 2 MAP-Reading score (RIT score) and Grade 1 prior RIT score, $R^2 = 0.64$, $p < .001$. 64% variances of the Grade 3 SBA-ELA score can be explained by the Grade 2 RIT score.

Quantile Regression

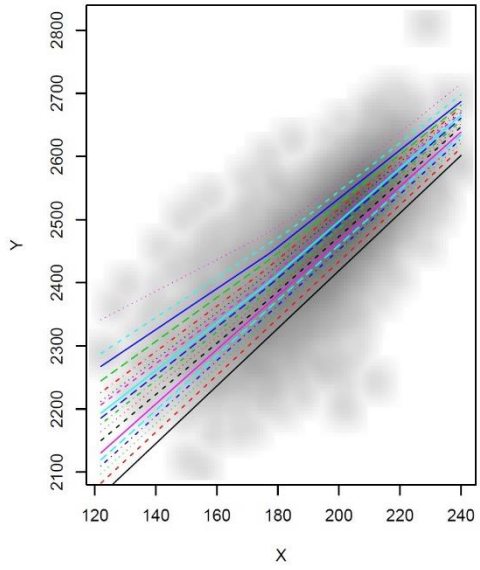
The SGPs are estimated using quantile regression methods (Koenker, 2005) by the SGP R package (Betebenner, 2011). R Package "quantregGrowth" is used to yield the quantile regression. The function is called by *gcrq* to fit growth charts based on regression quantiles with noncrossing quantile curves estimated as B-splines. In total, 11133 Grade 3 students combined of three years (2016-2018) with their prior MAP-reading score were included in the analysis. Their prior year scores of (2015-2017) were used for the covariate to predict their growth curve. We created the long format file with students' longitudinal data of (2015-2016, 2016-2017, 2017-2018) and their score from MAP reading score to SBA-ELA. The following are the (Growth chart) bivariate representation of linear and B-splines parametrization of growth curves from MAP Reading to SBA-ELA score of three years combined. for example, if the student score 182 on the prior test of Grade 2 MAP-reading, he/she should obtain a 1-99 percentile on the quantile regression plots for Grade 3 SBA-ELA score, if his/her current score is 2399 which falls between 50-51 percentile, the SGP of the current year is 50 percentiles. In such logic, each student can

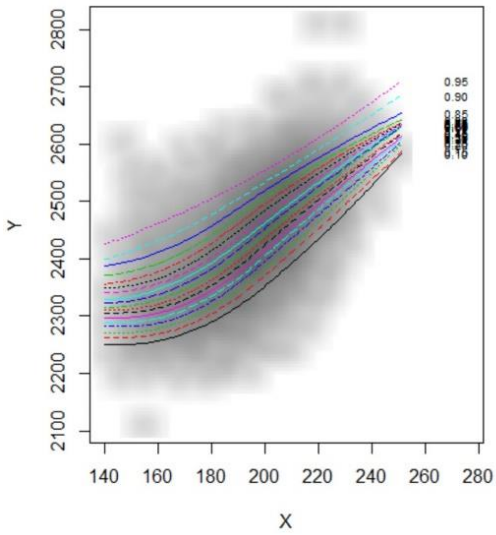
obtain the unique 1-99 quantile rank with cut-off score, the SGP package provides the closest SGP score to each student as the look-up table (See Appendix B).

Below are the conditional quantile functions as a linear combination of B-spline (figure 1) to the cubic basis functions (figure 2). By using quantile regression, the conditional density associated with each student's prior scores is derived and used to situate the student's most recent score. The following figures indicated the improvement from linear to B-spline regression, in which the conditional density fit better for the growth curve.

Figure 1 Linear regression lines with lambda=1000,

Figure 2 B-spline curve with 95% poitwise on confidence intervals.



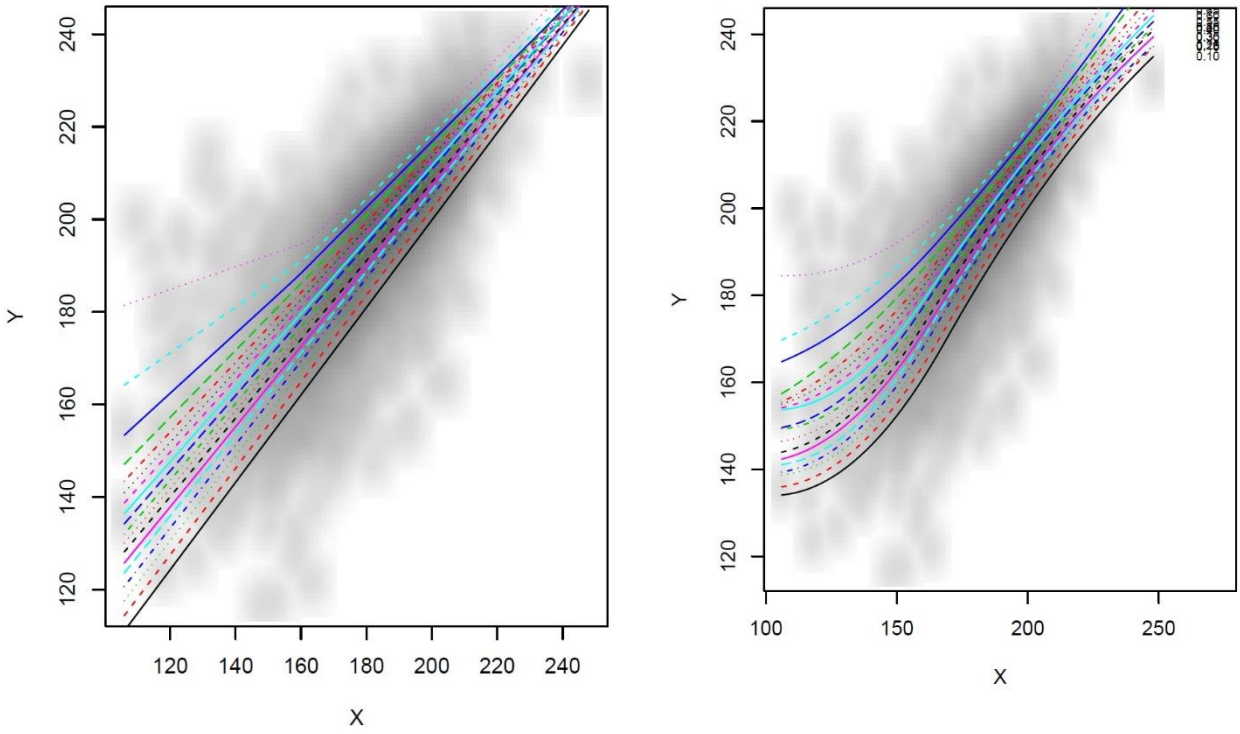


Another SGP analysis is applied to the Grade 1 to Grade 2 growth percentile for the students on the MAP-reading scores. In total, 11209 Grade 2 students combined with three years (2016-2018) were included in the analysis. Their prior year scores of (2015-2017) were used for the covariate to predict their growth in the current year. R package SGP was used to specify the quantiles to be used for the calculation of B-spline knots. A long format file was created with

students' longitudinal data of current the MAP reading score of Grade 2 and their prior score for Grade 1. We used the same way of statistical software R with an open-source software package SGP (Betebenner, Iwaarden, Domingue, & Shang, 2019) to create the look-up table for comprising student IDs associated with a range of growth percentile (1-99) with the cut-off score (See Appendix A). The following figures indicated the Quantile regression provides a more complete picture of both the conditional distribution associated with the response variable(s).

Figure 3 Linear regression lines with lambda=1000,

Figure 4 B-spline curve with 95% poitwise on confidence intervals.



Results

Using the three-year combined (2016-2018) SBA-ELA scores as the dependent variable, estimation of student growth percentiles was conducted exactly using the number of consecutive years by grade to estimate the growth from MAP-reading to SBA-ELA scores for each student. Student growth percentiles at the 1-99 percentiles were calculated based upon the prior year's

scale score. Results for the B-spline indicate the good-fit in the highest and lowest prior scale score. As with the low achievers in Grade 2 MAP-reading, the quadratic parameterization yields unbiased growth percentiles for low achieving students in Grade 3 ELA. By the same way, contrasting the linear results with the B-spline results for the Grade 2 students shows the impact that smoothing has improved on the goodness-of-fit from Grade 1 to Grade 2.

Goodness of Fit

We also generated the graphs to test the Goodness-of-Fit (GOF) for Student Growth Percentile including Ceiling/Floor Effect, decile student growth percentile range, and QQ-plots for Grade 2 MAP Reading SGP (2015-2016, 2016-2017, 2017-2018) (See Appendix C) and Grade 3 MAP Reading to SBA-ELA SGP (2015-2016, 2016-2017, 2017-2018) (See Appendix D). The results indicated high SGP GOF for 2015-2016 MAP Reading SGP (N = 3839). The proportions of high achievers (High OSS) and low achievers (Low OSS) are equally distributed to the SGP percentile range. On each decile matrix of SGP (1-9, 10-19, 20-29….90-99), the graph shows the proportion of numbers distribution. The QQ-plots shows some fuzzy between the theoretical and empirical distribution due to some slight disproportionate deciles in the Matrix, for example, the student's proportion only has 5.42% with a prior score between 180-184, which is far lower than the expected 10%. On the other hand, some decile proportion is higher as 13.27% with a prior score of 170-175, or 12.66%, etc. which add the fuzzy on the SGP distribution (See Appendix C). The results also show high goodness-of-fit for 2016-2017 MAP Reading SGP (N=3672), on the Ceiling/Floor graph, the proportions of high achievers and low achievers are equally distributed to the SGP percentile range, the QQ-plots shows the almost

linear regression of the empirical SGP distribution. The same pattern can be found for the 2017-2018 Reading SGP (N=3698).

Looking at the 2015-2016 ELA SGP Goodness-of-Fit for Grade 3 students, the proportions of high achievers (High OSS) and low achievers (Low OSS) are equally distributed. The QQ-plot shows some fuzzy on SGP decile proportion due to some disproportionate percentile ranges (See Appendix D). However, the GOF is higher on the 2016-2017 Grade 3 ELA SGP (N=3816). The Ceiling and Floor test indicated the fully equal distribution of high achievers (High OSS) and low achievers (Low OSS) on percentile range. However, the SGP Matrix still shows the flagged decile proportion with either higher or lower than 10% that makes the QQ-plots fuzzy. The Grade 3 ELA SGP GOF is highest for 2017-2018 (N=3636), on which the QQ-plots indicate a few disproportionate decile ranges.

Limits

Further study is considered to improve the validation of using quantile regression as the methodology to measure the student's growth. As the aggregated data with different grades and ethnicity, ELL-served groups might impact the results across the schools and district, using SGP should consider being unbiased for both low achievers to the high achievement on each decile of percentile. The results are appreciable to be fixed in the quadratic model. In the coming years, more research will be conducted to refine and validate student growth percentiles while reducing the bias of the underlying methodology.

Analysis

The following section compared with Grade 2 to Grade 4 Reading and SBA ELA Proficiency and SGP achievement. We Selection 13 elementary schools to be compared to the

other 64 elementary school for African American males (AAM) and Students of Color Furthest from Educational Justice (SOCFFEJ).

Background for selecting the 13 schools (……)

We run the descriptive analysis of *t* test to compare the group differences (treatment = 13, control = 64) for the SOCFFEJ and AAM students. For the SOCFFEJ students, the results did not indicated the statistically significant differences between the treatment and control group on Grade 2 Reading proficiency and SGP, $t(69)= 0.82$, $p = 0.42$, and SGP $t(69) = 0.026$, $p = 0.98$. We neither could find any statistically significant difference on the Grade 3 ELA proficiency, $t(69) = 1.63$, $p = 0.11$, and SGP, $t(69) = 0.40$, $p = 0.69$. The same pattern can be found on Grade 4 ELA proficiency and SGP, $t(69) = 1.50$, $p = 0.14$, and SGP, $t(69) = 0.41$, $p = 0.69$. For the AAM students, the results did not indicated the statistically significant differences between the treatment and control group on Grade 2 Reading proficiency and SGP, $t(52) = -0.81$, $p = 0.42$, and SGP $t(52) = -1.07$, $p = 0.29$. Neither do we find any statistically significant difference on the Grade 3 ELA proficiency, $t(52) = 0.29$, $p = 0.77$, and SGP, $t(52) = 1.15$, p-value = 0.25. We could not find any statistical significant difference on Grade 4 ELA proficiency, $t(52) = -0.5$, $p = 0.62$ and SGP $t(52) = -0.35$, $p = 0.73$.

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References

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Koenker, R., & Ng, P. (2005). Inequality constrained quantile regression. *Sankhyā: The Indian Journal of Statistics*, 418-440.