Colorado's Academic Growth Model

Report of the Technical Advisory Panel for the
Longitudinal Analysis of Student Assessment Convened
Pursuant to Colorado HB 07-1048

February 13, 2008

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EXECUTIVE SUMMARY

Over the last decade the Colorado Department of Education has actively pursued research, implementation, and reporting of analyses that take advantage of longitudinal student CSAP data. Legislation enacted in 2004 (HB 04-1433) established growth analysis techniques employed by the Colorado Department of Education (CDE) for diagnostic purposes. Building on this initiative, legislation enacted in 2007 (HB 07-1048) directed the CDE to refine the methodology established under HB 04-1433 to produce more useful information for schools and parents while expanding its use for accountability purposes. A technical advisory panel (TAP) was named by the Governor pursuant to law and tasked with recommending a model to the State Board of Education.

The TAP recommends the calculation of Student Growth Percentiles as the growth model best satisfying the requirements of HB 07-1048. Prior to making this recommendation and in accordance with statute, the TAP selected a qualified contractor, Dr. Damian Betebenner of the National Center for the Improvement of Educational Assessment, to develop the model and procedures used to derive Student Growth Percentiles and to provide technical advice on their implementation in a state accountability system.

Student Growth Percentiles (SGPs) will be calculated using a statistical technique known as quantile regression analysis. SGPs provide educational stakeholders (students, parents, teachers, principals, administrators, policy makers, and the public at large) an easily understood yet rigorous means by which to understand student progress given the vast amount of longitudinal data available. Calculated using a student's entire CSAP achievement history, student growth percentiles offer a normative measure of progress over time using students with the same prior academic standing as the comparison group (academic peers). Given this normative foundation, student growth percentiles can be used to quantify year-to-year growth, define what constitutes "typical growth" (or "one-year's growth in one-year's time"), and what constitutes "adequate growth" to reach proficient or advanced performance within a desired period of time (i.e., growth-to-state-standards).

Medians of SGPs can be used to quantify the level of student growth attained at specific schools and districts relative to other schools and districts within the State. Aggregation of the growth percentiles using the median presents a summary measure of student growth that informs judgments about school quality but does not imply causality. This means that while a school's contribution to student growth is reflected in the median growth percentile, the school's specific causal impact on learning cannot be discerned only from this single descriptive measure.

INTRODUCTION

Historical Perspective

House Bill 04-1433 (HB 04-1433) directed the Colorado Department of Education (CDE) to work with a Technical Advisory Committee (TAC) in the development and implementation of a statistical model capable of analyzing student growth. Following model specification in the summer of 2004, the state implemented a diagnostic growth model during the 2004-2005 school year based upon a mixed-effects design mandated by the legislation and discussed in detail in Betebenner & Doran (2004). CDE generated school level reports and distributed them to districts and charter schools in 2005. Data provided by the growth analyses served multiple purposes. Broadly, the analyses allow the State to determine an annual measure of growth for each student and to use that quantity to predict future achievement status for individual students.

The statistical model developed pursuant to HB 04-1433 had some shortcomings:

- The model fit a linear growth trajectory to each student and used that trajectory to predict future achievement. Longitudinal achievement for individual students across the vertical CSAP scale is not linear but displays a negative concavity. The use of a linear trend resulted in higher predicted achievement than was likely to occur for low achieving students.

- The percentage of students projected to be proficient was strongly correlated with current status measures and likely confounded growth of students at a given school with their initial status.

- House Bill 04-1433 specified that the results of the model be used to bestow Governor's Distinguished Improvement Awards to schools demonstrating outstanding student growth. No method for providing defensible aggregate measures of growth attributable to individual schools was agreed upon by the TAC.

- Based on the HB 04-1433 model, proper model identification requires a minimum of three time points for analysis. With such a requirement, the earliest that student projections would be available was after students complete the grade 5 CSAP test.

Authority to Revise Colorado's Longitudinal Model

House Bill 07-1048 (HB 07-1048) requires the CDE and a Technical Advisory Panel (TAP) appointed by the Governor to revise the growth model developed under HB 04-1433 to better quantify student growth (CRS § 22-7-604.3). The statute stipulates that the analysis of longitudinal growth should serve as the cornerstone of Colorado's education

accountability system. House Bill 07-1048 is attached to this report as Appendix A. The statute requires the dissemination of a report describing the longitudinal growth model recommended by the TAP, which this report accomplishes.

To be congruent with HB 07-1048, the recommended model should have the following properties: (1) utilizes all available scores of students, (2) includes students with sparse data and accommodates students retained in grade, (3) accounts for the influence of artificially high or low scoring students, and regression toward the mean, (4) is in the public domain and is well documented, (5) is replicable by other statisticians, (6) produces defensible school and student level measures of growth, (7) provides standard error estimates of statistics used in the accountability setting, and (8) is a scientifically rigorous statistical model.

House Bill 07-1048 asks the Colorado Department of Education to refine the current methodology to determine what amount of achievement growth constitutes one-year's growth in one-year's time and what amount constitutes "adequate growth" to reach proficient or advanced performance within a period of time. As specified in HB 07-1048, the statistical model being recommended for adoption should:

1. Provide information that supports improving students' academic achievement and the closing of the achievement gap.
2. Indicate how many and which students make at least a year's growth in a year's time.
3. Identify how many and which students are on pace to reach proficient or advanced performance in the next three years, or by grade 10.
4. Produce student-level and school-level reports of academic growth.
5. Support an accountability system that "encourages and supports teachers in meeting the needs of all students."
6. Produce school level measures of student growth appropriate for use as criteria in administering the Governor's Distinguished Improvement Awards.

Beginning in April 2007, the TAP has worked closely with the CDE to fulfill the expectations of HB 07-1048. This report is a summary of the work undertaken and the recommendations of the TAP in accordance with that statute.

THE RECOMMENDED STATISTICAL MODEL

Discussions within this section of the report are intended to be conceptual in nature rather than technical. Appendix B provides technical information regarding the recommended model. The TAP charged with recommending a longitudinal model that fulfills the requirements of HB 07-1048 considered a variety of issues while preparing its recommendation, including the roles of statistical models vs. accountability systems.

Statistical Models vs. Accountability Systems

It is important to distinguish between (1) statistical models of growth and (2) the accountability systems that may be based on statistical model outputs. For instance, an estimate of student growth over multiple years may be derived from various mixed models as a slope (or linear growth rate). For each student, the associated slope estimate is an output of the statistical model. The inferences drawn regarding the meaning of those slopes is a function of the accountability system. The model estimates what has occurred; the accountability system utilizes those estimates to make value judgments regarding the acceptability of the measured progress.

As statistical models were considered by the TAP, two questions were investigated simultaneously: (1) How well (accuracy and defensibility) does a model measure what has occurred at the student as well as the school level regarding academic growth? (2) How useful (actionable) are the results from these statistical models for stakeholders at the school, state, and national level? An accountability system is likely to foster sustained improvement in educational practice if the information it generates is useful for developing strategies to maximize student progress over time. Productive discussions are more likely if stakeholders understand that the measures used are fair, transparent, and valid.

Student Growth Percentiles

The recommended statistical model calculates a student growth percentile (SGP) for each student based on all other students with the same achievement history. The SGP provides a measure of academic growth where students who have similar academic score histories provide a baseline for understanding each student's progress. "Academic peers" are all students in the same grade being tested in the same subject and having a similar CSAP score history in that subject prior to the current year. For example, if a student's growth percentile is 72, then the student's growth was as good as or better than 72% of that student's academic peers.

The recommended longitudinal growth model uses quantile regression to estimate SGP's for each student in the state who completes at least two successive CSAP tests in at least one academic subject. Quantile regression is a statistical regression procedure where

conditional quantiles (e.g., conditional percentiles) are estimated rather than simply the conditional mean, as in typical regression procedures. The individual student growth percentiles estimated through use of quantile regression will be used to determine (1) how much growth the same students made from year to year–expressed as a SGP with the 50^{th} percentile representing typical growth or "one-year's growth in one year's time," (2) the adequacy of students' growth—expressed as the SGPs necessary for a student to reach proficient and advanced levels of achievement within one, two, and three years).

Medians of the individual SGPs, an aggregated summary measure of student growth, will be computed for schools based on all qualified SGPs as determined by the CDE. Criteria for determining which SGPs are qualified for inclusion in school medians should be aligned with the criteria used in computing School Accountability Report (SAR) growth measures. The median SGP computed for each school serves as an indicator of student growth associated with each school but does not imply causality. That is, median SGPs as calculated do not isolate a specific school "effect." This means that while a school's contribution to student growth is reflected in the median SGP, the school's specific causal impact on learning cannot be discerned only from this single descriptive measure.

The median SGP describes a characteristic of a school's students as a group and can be used to evaluate school outcomes. The median SGP measures the relative growth that has occurred for the group of students attending a specific school. This distinction between descriptively measuring what has occurred as opposed to quantifying a causal influence is important when policy makers consider ramifications for schools or programs associated with different growth rates. The TAP recommends that stakeholders place a greater emphasis on sustained trends in growth among schools (median SGPs across more than one cohort of students) than on year-to-year changes in growth.

The TAP's intent is that the information conveyed through SGPs will encourage meaningful conversations among stakeholders in the education community to enhance educational opportunities for all of Colorado's students. The calculation of SGPs should allow the state and our education community to:

(1) Focus incentives on maximizing the academic growth of all students, rather than students closest to a particular performance level.
(2) Target support to schools with low growth and low achievement levels.
(3) Identify schools and districts with high sustained growth as exemplars for other schools and districts.
(4) Provide teachers, school leaders, and parents with actionable information to support continuous school improvement while serving public accountability purposes.

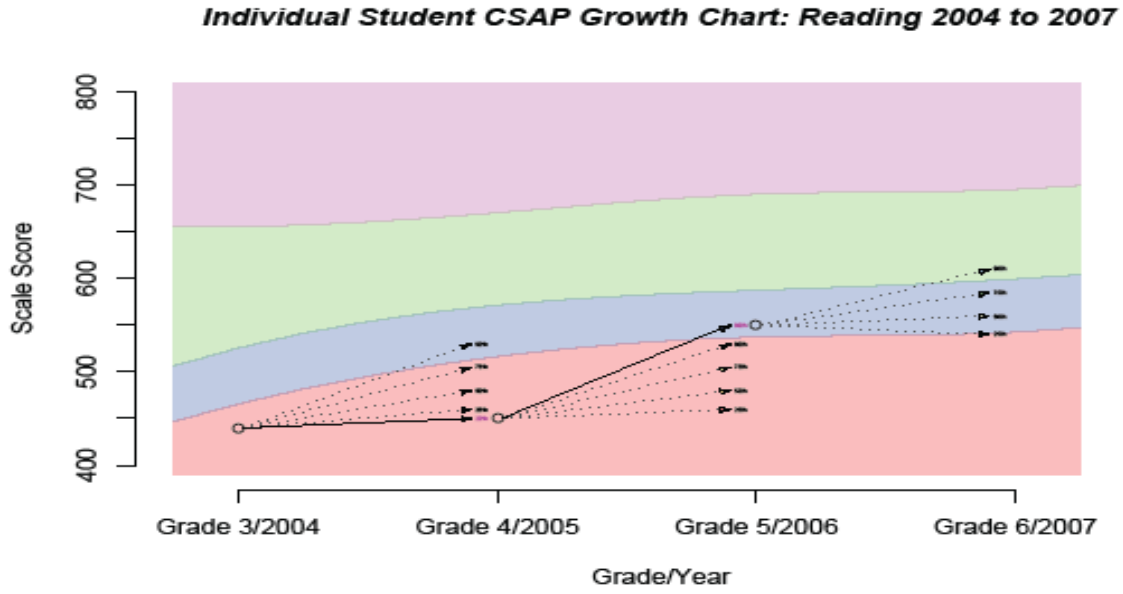
POTENTIAL REPORT TEMPLATES

The following graphs are examples of the types of reports that can be produced based on SGPs. The TAP asks the CDE to provide districts and schools with interactive graphical displays that can be used to gain insight into student growth and achievement levels at the individual student level, the school level, and the district level. The TAP has reviewed the following displays and supports their further development and deployment by CDE.

Student-Level Reports

The Individual Student CSAP Growth Chart below describes a single student's progression in reading from 2004 through 2007. The vertical axis is the CSAP scale score continuum for the Reading tests. The horizontal axis designates the grade and academic year of the CSAP test. The four colors in the background represent the performance levels associated with various CSAP scale scores across the grade levels depicted. The lowest color (orange) designates the unsatisfactory performance level. Blue represents the partially proficient performance level. Green represents proficient scale score results and magenta (the top color) represents the advanced category.

The graph shows what has occurred prior to 2006 (descriptive) and what different growth percentiles would result in with respect to achievement level in 2007 (prognostic). The solid arrows leading from one year to the next indicate the actual SGP the student realized in one year. The dotted lines represent the range of SGPs for the student's academic peers.

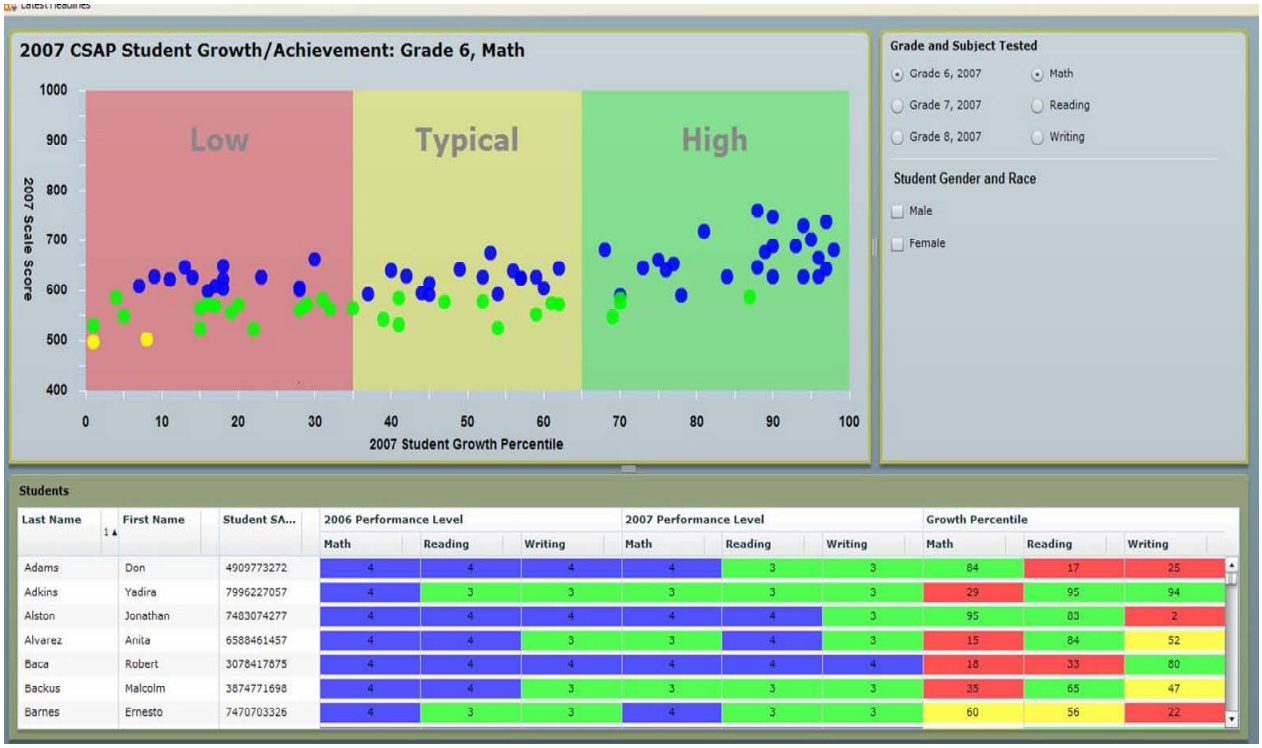


School-Level Reports

In the School Level Report displayed below, each dot represents a single student within a school. The dot's color represents the four levels of performance; blue is advanced, lime green is proficient, and bright yellow is partially proficient. The vertical axis is the CSAP scale score continuum for the Math tests, similar to the vertical axis of the student-level report. The horizontal axis indicates the 2007 SGP, where vertical color codes designate three regions of growth; red is low growth, yellow is typical growth, and green is high growth.

The tabled values below the scatter plot show math, reading, and writing performance levels and the growth percentiles for each student in the school. The students' names and the related State Assigned Student IDs are fictitious in the table portion of Figure 2; no row of the table contains real student information.

The School Level Report also contains optional selection buttons that can limit the displayed data to only those students in a specific grade, testing in a specific subset of academic subjects, or students of a specific gender, ethnicity, or socioeconomic status.

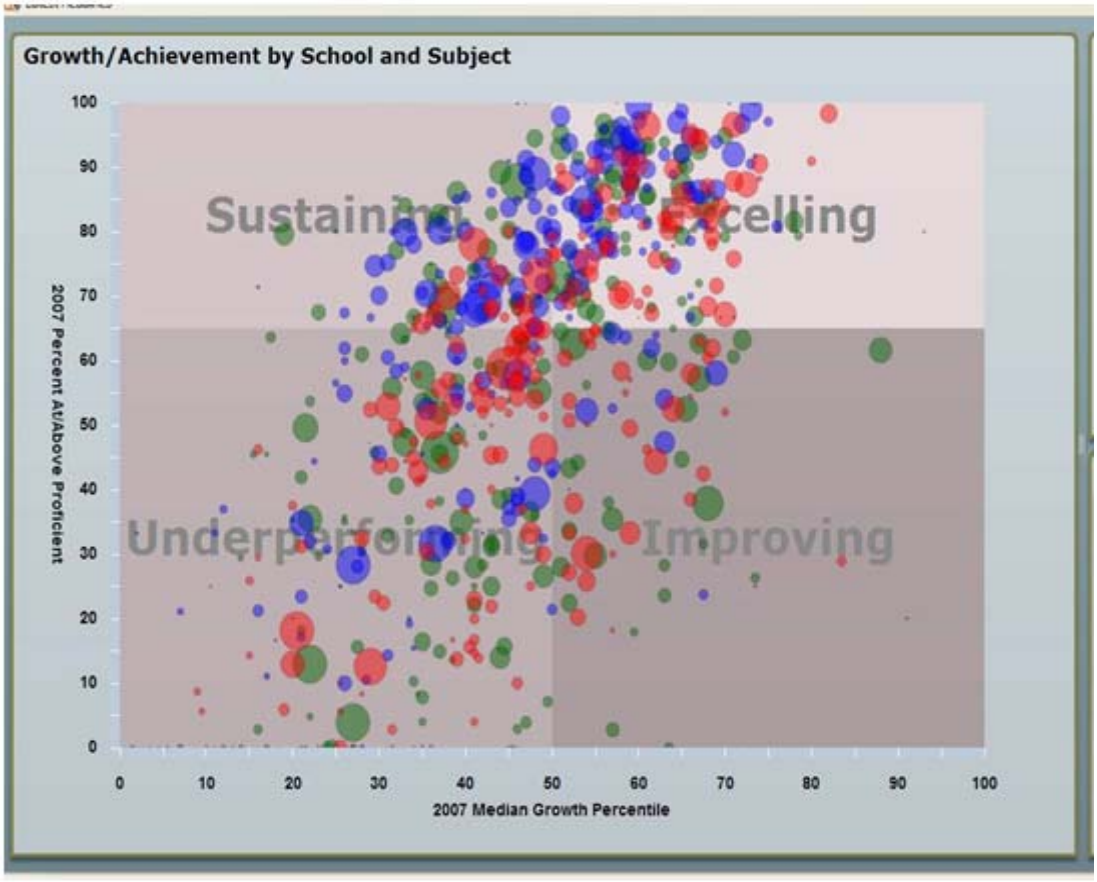


Last Name	First Name	Student SA...	2006 Performance Level			2007 Performance Level			Growth Percentile		
			Math	Reading	Writing	Math	Reading	Writing	Math	Reading	Writing
Adams	Don	4909773272	4	4	4	4	3	3	84	17	25
Adkins	Yadira	7996227057	4	3	3	3	3	3	29	95	94
Alston	Jonathan	7403074277	4	4	4	4	4	3	95	00	2
Alvarez	Anita	6588461457	4	4	3	3	4	3	15	84	52
Baca	Robert	3078417875	4	4	4	4	4	4	18	33	80
Backus	Malcolm	3874771698	4	4	3	3	3	3	35	65	47
Barnes	Ernesto	7470703326	4	3	3	4	3	3	60	56	22

District-Level Report

Each dot in the District Level Report below represents a single school within a district. The size of the dot corresponds to size of enrollment. A dot's color represents academic subject (blue = reading, green = math, and red = writing). The vertical axis designates the percentage of students that are proficient or advanced in a school based on the 2007 CSAP. The horizontal axis is the continuum of growth rates expressed as median SGPs. The background is divided into four regions labeled Excelling, Sustaining, Improving, and Underperforming.

- Schools represented by a dot in the Excelling region served students for whom growth was high and achievement levels (the percentage of proficient and advanced students) were also high.
- Schools in the Improving region served students for whom growth was high and achievement levels were low.
- Schools in the Sustaining region served students for whom growth was low and achievement levels were high.
- Schools in the Underperforming region served students for whom growth was low and achievement levels were also low.



The District Level Report contains optional selection buttons that can limit the displayed data to only those students in a specific school type (elementary, middle, high) or tested in a specific academic subject. The vertical axis can also be selected to display the school's percent of proficient or advanced students based on 2006 CSAP results or 2007 CSAP results.

IMPLEMENTATION TIMELINE

The Technical Advisory Panel recommends that the CDE distribute SGP results to districts at least one full week before the public release of CSAP scores. While statute permits the CDE to distribute results as late as August 15th, students will benefit more if districts receive these results in time for trainings with principals, which often take place in late July. The TAP recognizes that CDE may need to distribute results in waves, with files containing raw data being distributed in advance of more elegant graphical displays.

REFRENCES

Betebenner, D. W., & Doran, H. C., (2004, October). Analyses in Support of House Bill 04-1433. Internal Technical Report, Colorado Department of Education. (Report produced for the use of Colorado Department of Education in support of HB 04-1433)

APPENDIX A
House Bill 07-1048

NOTE: This bill has been prepared for the signature of the appropriate legislative officers and the Governor. To determine whether the Governor has signed the bill or taken other action on it, please consult the legislative status sheet, the legislative history, or the Session Laws.

An Act

HOUSE BILL 07-1048

BY REPRESENTATIVE(S) Merrifield, Balmer, Benefield, Borodkin, Butcher, Carroll M., Carroll T., Casso, Fischer, Frangas, Gallegos, Gardner C., Green, Hicks, Hodge, Jahn, Kefalas, Kerr A., Labuda, Lambert, Levy, Madden, Massey, May M., McFadyen, McGihon, Mitchell V., Peniston, Primavera, Rice, Riesberg, Romanoff, Solano, Soper, Stephens, Summers, Todd, and White;
also SENATOR(S) Windels, Bacon, Boyd, Fitz-Gerald, Gordon, Groff, Harvey, Isgar, Keller, Mitchell S., Morse, Penry, Romer, Sandoval, Schultheis, Schwartz, Shaffer, Tapia, Tochtrop, Tupa, Veiga, Ward, Wiens, and Williams.

CONCERNING LONGITUDINAL ANALYSIS OF STUDENT ASSESSMENTS.

Be it enacted by the General Assembly of the State of Colorado:

SECTION 1. Legislative declaration. (1) The general assembly hereby finds and declares that:

(a) Since 1997, the general assembly has directed the department of education to develop the tools and expertise necessary to perform longitudinal analysis of student assessment results and to provide diagnostic information to assist school districts, schools, teachers, and parents in improving students' academic achievement and closing the achievement

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Capital letters indicate new material added to existing statutes; dashes through words indicate deletions from existing statutes and such material not part of act.

gap;

(b) The general assembly has demonstrated a high interest in longitudinal analysis of student assessment results based on legislation passed and appropriations made annually since 2001.

(c) Colorado has the opportunity to apply by February 2007 to the United States department of education for flexibility in incorporating longitudinal growth models in the determination of adequate yearly progress under the requirements of the federal "No Child Left Behind Act of 2001", Pub.L. 107-110;

(d) While it is acknowledged that the department of education's inability to spend resources is in part due to the off-budget funding mechanism that makes it difficult to expend dollars until halfway through the fiscal year.

(e) House Bill 07-1048 can be implemented using the existing resources and full-time equivalent employees appropriated to the department of education for fiscal year 2006-07 for development and implementation of a longitudinal growth model.

SECTION 2. 22-7-604.3, Colorado Revised Statutes, is amended to read:

22-7-604.3. Academic growth calculation - model - rule-making. (1) **Legislative declaration.** (a) The general assembly hereby finds, determines, and declares that:

(I) In 1993, the general assembly adopted House Bill 93-1313, establishing state model content standards in several areas, including reading, writing, and mathematics, and directing school districts to adopt district standards in these areas;

(II) The state model content standards were designed to measure what each child should know and be able to do at various levels of development in the child's academic career;

(III) In 1997, Colorado began implementing the Colorado student assessment program to measure whether students were successfully meeting

the state model content standards;

(III.5) SINCE 1997, THE GENERAL ASSEMBLY HAS DIRECTED THE DEPARTMENT TO DEVELOP THE TOOLS AND EXPERTISE NECESSARY TO PERFORM LONGITUDINAL ANALYSIS OF STUDENT ASSESSMENT RESULTS, AND TO PROVIDE INFORMATION TO ASSIST SCHOOL DISTRICTS, SCHOOLS, TEACHERS, AND PARENTS IN IMPROVING STUDENTS' ACADEMIC ACHIEVEMENT AND CLOSING THE ACHIEVEMENT GAP. HOWEVER, DESPITE THE PROVISION OF STATE FUNDING AND CLEAR STATUTORY DIRECTION BY THE GENERAL ASSEMBLY, THE DEPARTMENT HAS NOT YET TAKEN THE STEPS NECESSARY TO MAKE LONGITUDINAL DATA USEFUL TO STUDENTS, PARENTS, TEACHERS, OR ADMINISTRATORS AT THE SCHOOL LEVEL.

(IV) A next step in ~~implementing content standards in education is to identify how much academic growth is required to meet each level of content standard and to measure whether students are achieving this growth~~ MEASURING STUDENT PROGRESS IN MEETING THE STATE MODEL CONTENT STANDARDS IS TO INCORPORATE A LONGITUDINAL GROWTH COMPONENT THAT INDICATES HOW MANY AND WHICH STUDENTS MAKE AT LEAST A YEAR'S ACADEMIC GROWTH IN A YEAR'S TIME, WHILE ALSO IDENTIFYING HOW MANY AND WHICH STUDENTS ARE ON PACE TO BE PARTIALLY PROFICIENT, PROFICIENT, OR ADVANCED, DEPENDING ON THE STUDENTS' STARTING LEVELS, WITHIN THE NEXT THREE YEARS;

(IV.3) THIS INFORMATION ON THE LONGITUDINAL GROWTH OF STUDENTS SHOULD BE THE CORNERSTONE OF THE STATE'S EDUCATIONAL ACCOUNTABILITY SYSTEM;

(IV.7) SCHOOLS AND THE PUBLIC WILL BE BEST SERVED BY A SCHOOL ACCOUNTABILITY SYSTEM THAT IS BASED ON LONGITUDINAL GROWTH, PROVIDES CONSISTENT INFORMATION, AND ENCOURAGES AND SUPPORTS TEACHERS IN MEETING THE NEEDS OF ALL STUDENTS;

(V) The goal for most students, no matter where a student starts, is to achieve yearly academic growth sufficient to perform at least at the proficiency level of "proficient" in reading, writing, and mathematics by the time the student completes grade ten. In the case of students who have not yet completed grade ten but who are performing at the proficiency level of "proficient" or "advanced" in reading, writing, or mathematics on CSAP assessments administered at their respective grades, the goal for such

students is to advance from year to year in a way that maintains or improves upon their proficiency level performance.

(V.3) A LONGITUDINAL GROWTH COMPONENT THAT HAS UNIVERSAL PROFICIENCY FOR STUDENTS AS ITS AIM IS CRITICAL TO A SCHOOL ACCOUNTABILITY SYSTEM BECAUSE IT ARTICULATES A MEANINGFUL GOAL FOR EACH STUDENT REGARDLESS OF THE CURRENT LEVEL OF PERFORMANCE FOR THAT STUDENT;

(V.5) A LONGITUDINAL GROWTH COMPONENT SHOULD MEASURE GROWTH TOWARD A STANDARD AND DETERMINE THE AMOUNT OF GROWTH A STUDENT IS MAKING TOWARD PARTIALLY PROFICIENT, PROFICIENT, AND ADVANCED PERFORMANCE. OTHER CHARACTERISTICS OF A HIGH-QUALITY LONGITUDINAL GROWTH COMPONENT SHOULD INCLUDE:

(A) IDENTIFYING HOW MANY AND WHICH STUDENTS WHO ARE NOT YET PROFICIENT ARE ON PACE TO BECOME PROFICIENT;

(B) IDENTIFYING HOW MANY AND WHICH STUDENTS WHO ARE PROFICIENT ARE ON PACE TO REMAIN PROFICIENT; AND

(C) IDENTIFYING HOW MANY AND WHICH STUDENTS WHO ARE ALREADY PROFICIENT OR ADVANCED ARE ON PACE TO MOVE UP ON THE ADVANCED END OF THE ACHIEVEMENT DISTRIBUTION.

(V.7) ANOTHER ASPECT OF A HIGH-QUALITY LONGITUDINAL GROWTH COMPONENT WILL BE THE ABILITY TO PROVIDE RELIABLE, VALID, AND MEANINGFUL RESULTS TO EXTERNAL STAKEHOLDERS TO ENABLE THEM TO JUDGE ACADEMIC IMPROVEMENT AND HOLD THE EDUCATIONAL SYSTEM ACCOUNTABLE;

(VI) WITH A LONGITUDINAL GROWTH MODEL IN PLACE, the numeric CSAP scores received by each student in successive school years ~~can be used to provide a diagnostic measure that~~ will indicate the student's degree of academic growth over time;

(VII) Measuring each student's academic growth over time will provide necessary ~~diagnostic~~ information to assist parents, teachers, schools, and school districts in identifying students who need additional assistance and will help to close the learning gap that sometimes exists

among students in the same classrooms;

(VIII) The ~~diagnostic~~ measurement of student academic growth over time should be based upon all available individual scores for the student on statewide assessments administered to the student through the years; and

(IX) The ~~diagnostic~~ methodology of calculating student academic growth over time should be capable of accommodating the inclusion of all students, including students for whom sparse data is available.

(b) The general assembly further finds and declares that:

(I) Efforts to improve student academic growth should emphasize closing achievement gaps;

(II) A true longitudinal measure is required that tracks individual students from one grade level in the first year to the next higher grade level in the following year and that accommodates students retained in grade;

(III) Only students who were enrolled in a school by October 1 of the school year should have their academic growth included in the school's overall academic growth rating for that school year in the school accountability report;

(IV) An academic growth measurement should account for the influence of artificially high- or low-scoring students and regression toward the mean;

(V) Credit should be given for students who maintain their performance at the advanced level of proficiency, even if their scale scores decline, to recognize the substantial amount of learning required to maintain that level of performance and to avoid penalizing schools with large numbers of advanced-level students whose scores might decline slightly due to measurement error;

(V.5) AN ACADEMIC GROWTH MEASUREMENT WILL SET THE PROPER TENSION BY FOCUSING ATTENTION ON ALL STUDENTS. AN ACADEMIC GROWTH MEASUREMENT WILL NOT ONLY DEFINE WHAT CONSTITUTES A YEAR'S ACADEMIC GROWTH IN A YEAR'S TIME BUT IT WILL IDENTIFY HOW MANY AND WHICH STUDENTS MAKE A YEAR'S ACADEMIC GROWTH IN A

YEAR'S TIME, WHILE ALSO PROVIDING USEFUL INFORMATION ON EACH STUDENT WITH RESPECT TO THE PROVISIONS OF SUBPARAGRAPH (V.5) OF PARAGRAPH (a) OF THIS SUBSECTION (1).

(VI) An academic growth measurement should ~~measure~~ GAUGE each student's progress toward performing at the proficiency level of "advanced" or "proficient";

(VII) An academic growth measurement should measure the performance over time of students assigned to specific classrooms and teachers; and

(VIII) Teachers should be able to identify individual students who are not making sufficient progress and to use the ~~diagnostic~~ properties of CSAP's objectives to plan instructional strategies for improvement.

(c) Therefore, it is the intent of the general assembly to adopt legislation to implement a process for ~~diagnostically~~ measuring student academic growth and to include a longitudinal student academic growth measurement on the school accountability report that will:

(I) Create a cooperative atmosphere among students, parents, teachers, school district administrators, the department of education, and the state board of education; and

(II) Promote the highest possible academic achievement FOR ALL STUDENTS, INCLUDING MOVING STUDENTS FROM UNSATISFACTORY TO PARTIALLY PROFICIENT, PARTIALLY PROFICIENT TO PROFICIENT, AND PROFICIENT TO ADVANCED, AND ENSURING STUDENTS WHO SCORE ADVANCED CONTINUE TO SCORE ADVANCED.

(2) **Development of model - technical advisory panel.** (a) Within fifteen days after ~~June 3, 2004~~ RECEIPT OF THE RECOMMENDATIONS OF THE TECHNICAL ADVISORY PANEL PURSUANT TO SUBPARAGRAPH (I) OF PARAGRAPH (b) OF THIS SUBSECTION (2), the department shall choose ~~a~~ AN EXPERIENCED public or private entity, ~~to develop,~~ WITH A STRONG NATIONAL REPUTATION, TO REVISE THE LONGITUDINAL GROWTH MODEL DEVELOPED PRIOR TO JANUARY 1, 2007, PURSUANT TO SUBSECTION (3) OF THIS SECTION TO ENSURE THAT IT IS APPROPRIATE FOR DESIGNATING LONGITUDINAL GROWTH ACHIEVEMENT FOR INDIVIDUAL SCHOOLS AND THAT IT CONSIDERS

STATE LONGITUDINAL GROWTH MODELS APPROVED BY THE UNITED STATES DEPARTMENT OF EDUCATION. No later than ~~June 15, 2004 a~~ SIXTY DAYS AFTER BEING CHOSEN, THE CONTRACTOR SHALL ADAPT AN EXISTING mixed-effects statistical model FOR USE IN COLORADO to ~~diagnostically~~ calculate students' annual academic growth and to calculate annually the amount of each student's and each school's academic growth in reading, writing, and mathematics over the periods between the administration of the CSAP assessments, which calculation shall be based on students' CSAP scores.

(a.5) THE CONTRACTOR CHOSEN PURSUANT TO PARAGRAPH (a) OF THIS SUBSECTION (2) SHALL UTILIZE A MODEL IN THE PUBLIC DOMAIN THAT IS NOT PROPRIETARY AND IS FULLY AND ACCURATELY EXPLAINED, INCLUDING THE GENERATION OF ALL RESULTS, IN A PUBLISHED DOCUMENT THAT IS AVAILABLE TO THE PUBLIC. THE MODEL THAT THE CONTRACTOR GENERATES SHALL BE ONE THAT CAN BE REPLICATED BY ANY INDEPENDENT STATISTICIAN. INCLUDED IN THE SCOPE OF WORK FOR THE CONTRACTOR SHALL BE THE EXTENSION OF THE LONGITUDINAL GROWTH CALCULATION DEVELOPED PURSUANT TO THIS SECTION TO THE SCHOOL LEVEL WITH THE INTENT THAT IT BE THE BASIS FOR ALL ACADEMIC ACCOUNTABILITY.

(b) (I) No later than ~~June 15, 2004~~ FIFTEEN DAYS AFTER THE EFFECTIVE DATE OF HOUSE BILL 07-1048, the GOVERNOR SHALL APPOINT AND THE department shall convene a technical advisory panel that ~~includes~~ SHALL INCLUDE STATE AND NATIONAL experts on the measurement of longitudinal growth for accountability purposes. ALL MEETINGS OF the technical advisory panel shall be open.

(II) AT IT'S FIRST MEETING, THE TECHNICAL ADVISORY PANEL SHALL RECOMMEND TO THE DEPARTMENT ONE OR MORE CONTRACTORS TO ADAPT A STATISTICAL MODEL PURSUANT TO PARAGRAPH (a) OF THIS SUBSECTION (2). THE TECHNICAL ADVISORY PANEL SHALL review the proposed model developed pursuant to paragraph (a) of this subsection (2) for ~~diagnostically~~ calculating the annual academic growth of students AND SCHOOLS. The model, at a minimum, shall specify the standard error of measurement and shall specify the stringency of the confidence interval used to determine whether the annual change in test scores can be attributable to chance due either to measurement error or to regression to the mean. In reviewing the model, the TECHNICAL advisory panel shall consider recent national studies of different methodologies and VARIOUS models for measuring longitudinal

growth, INCLUDING LONGITUDINAL GROWTH MODELS THAT THE UNITED STATES DEPARTMENT OF EDUCATION HAS APPROVED FOR USE BY STATES AS PART OF STATE PLANS TO MEET THE ADEQUATE YEARLY PROGRESS REQUIREMENTS OF THE FEDERAL "NO CHILD LEFT BEHIND ACT OF 2001", PUB.L. 107-110.

(c) No later than ~~July 1, 2004~~ THIRTY DAYS AFTER THE ADAPTATION OF THE MODEL PURSUANT TO THIS SUBSECTION (2), the TECHNICAL ADVISORY panel convened pursuant to paragraph (b) of this subsection (2) shall submit its written ~~comments or~~ FINDINGS AND recommendations CONCERNING THE LONGITUDINAL GROWTH MODEL to the department, the state board, the education committees of the senate and the house of representatives, OR ANY SUCCESSOR COMMITTEES, and the governor. THE DEPARTMENT SHALL MAKE THE FINDINGS AND RECOMMENDATIONS ELECTRONICALLY AVAILABLE TO THE PUBLIC AND SHALL PROMPTLY NOTIFY PERSONS WHO REQUEST NOTICE OF WHEN AND WHERE TO OBTAIN THE ELECTRONIC COPIES OF THE FINDINGS AND RECOMMENDATIONS.

(d) The department shall convene the panel described in paragraph (b) of this subsection (2) within existing appropriations.

(3) **Academic growth calculation model.** (a) On or before ~~August 15, 2004~~ THIRTY DAYS AFTER THE RECEIPT OF THE RECOMMENDATIONS OF THE TECHNICAL ADVISORY PANEL PURSUANT TO PARAGRAPH (c) OF SUBSECTION (2) OF THIS SECTION, the state board shall consider the model developed pursuant to subsection (2) of this section and ~~reviewed by~~ THE FINDINGS AND RECOMMENDATIONS OF the technical advisory panel and shall adopt by EMERGENCY rule a mixed-effects statistical model used to ~~diagnostically~~ calculate ~~students'~~ THE annual academic growth OF STUDENTS AND SCHOOLS that shall be a scientifically rigorous statistical model available in the public domain. AFTER THE PROMULGATION OF THE EMERGENCY RULE, THE STATE BOARD SHALL PROMULGATE PERMANENT RULES ON ADOPTING THE STATISTICAL MODEL. The state board may adopt a hierarchical linear model as the statistical model OR SOME VARIATION OF SUCH A MODEL.

(b) The state board, in adopting the statistical model described in paragraph (a) of this subsection (3), shall ensure that the model:

(I) Reflects best practices, as acknowledged in the scientific

literature, in measuring longitudinal growth with high precision;

(II) To the greatest extent possible, uses a methodology that will serve the ~~diagnostic~~ purposes of SCHOOLS AND school districts; ~~and schools;~~

(III) Is capable of measuring how much progress a student is making toward performing at the proficiency level of "PARTIALLY PROFICIENT", "proficient", or "advanced" on CSAP assessments;

(III.5) IS CAPABLE OF GAUGING HOW SUCCESSFUL EACH STUDENT WILL BE IN MAKING ONE YEAR'S ACADEMIC GROWTH IN ONE YEAR'S TIME;

(IV) Provides results that are meaningful, reliable, and valid, given their intended purposes, to enable parents, teachers, and administrators to identify individual students or groups of students who ARE AND are not making sufficient academic growth;

(IV.5) RECOGNIZES IMPROVEMENT OF STUDENTS WHOSE SCALE SCORES INCREASE EVEN IF THEY DO NOT INCREASE TO A HIGHER CSAP PERFORMANCE LEVEL;

(V) Uses individual student scores from CSAP assessments;

(VI) Is described in a publicly available document that ~~describes~~ SETS FORTH the mathematical equations used in the statistical model and that ~~describes~~ FULLY AND ACCURATELY EXPLAINS the methods used to complete the records for students with incomplete data; and

(VII) Is capable of treating the analysis and reporting of data electronically AND PRODUCES STUDENT- AND SCHOOL-LEVEL REPORTS THAT MAY BE DELIVERED ON OR BEFORE SEPTEMBER 15, 2007, AND ON OR BEFORE SEPTEMBER 15 OF EACH YEAR THEREAFTER.

(4) **Adequate academic growth.** (a) No later than ~~September 15, 2004~~ AUGUST 15, 2007, AND NO LATER THAN AUGUST 15 EACH YEAR THEREAFTER, the department shall calculate what constitutes ~~sufficient~~ ADEQUATE LONGITUDINAL academic growth for each student for each school year. The department shall formulate the calculation in such a way that ~~sufficient~~ ADEQUATE LONGITUDINAL academic growth means:

(I) A student is progressing ~~sufficiently~~ ADEQUATELY to perform in reading, writing, and mathematics at increasing levels of proficiency, projected at grade levels determined by the department, in consultation with the technical advisory panel, with the goal of performance at least at the proficiency level of "proficient" before completing grade ten; and

(II) For a student who is performing at the proficiency level of "advanced", the student is progressing from year to year in a way that maintains or improves upon the student's proficiency level performance.

(b) The department shall use data available for longitudinal analysis to review and revise the calculation of academic growth as necessary.

(5) **Academic growth information - rule-making.** (a) Beginning in the ~~2004-05~~ 2007-08 school year, the department shall provide to each school district in the state ~~diagnostic~~ academic growth information for each student enrolled in the school district and for each public school in each school district, based on the CSAP assessment results for the preceding school years.

(b) Beginning in the ~~2004-05~~ 2007-08 school year, the department shall provide to each charter school in the state ~~diagnostic~~ academic growth information for each student enrolled in the charter school, based on the CSAP assessment results for the preceding school years. The department shall ensure that data provided to a charter school pursuant to this paragraph (b) include only the data for students enrolled in the charter school.

(b.5) THE ACADEMIC GROWTH INFORMATION REQUIRED BY PARAGRAPHS (a) AND (b) OF THIS SUBSECTION (5) SHALL INCLUDE INFORMATION ON WHETHER EACH STUDENT MADE AT LEAST ONE YEAR'S ACADEMIC GROWTH IN ONE YEAR'S TIME AND WHETHER THE AMOUNT OF ACADEMIC GROWTH IS ADEQUATE FOR THE STUDENT TO REACH A PERFORMANCE LEVEL OF PROFICIENT WITHIN THREE YEARS OR BY GRADE TEN, WHICHEVER COMES SOONER. FOR STUDENTS WHO ARE ALREADY PROFICIENT, THE ACADEMIC GROWTH INFORMATION SHALL SPECIFY WHETHER THE STUDENT IS ON PACE TO REMAIN PROFICIENT OR WHETHER THE STUDENT IS ON PACE TO MOVE INTO THE UPPER RANGE OF THE ACHIEVEMENT DISTRIBUTION; EXCEPT THAT A DIFFERENT INTERVAL MAY BE SELECTED BY THE DEPARTMENT IF RECOMMENDED BY THE TECHNICAL ADVISORY PANEL.

(c) Repealed.

(d) ~~The state board shall promulgate rules establishing the procedures by and time frames in which the department shall provide the diagnostic academic growth information to school districts and to charter schools pursuant to this subsection (5). The department may provide the diagnostic academic growth information in an electronic format.~~

(e) The department and school districts shall maintain the confidentiality of each student's CSAP scores consistent with the federal "Family Educational Rights and Privacy Act of 1974", 20 U.S.C. sec. 1232g, and all federal regulations and applicable guidelines adopted in accordance therewith.

(f) The ~~diagnostic~~ academic growth information provided by the department shall be included in each student's individual student record maintained by the school district in which the student is enrolled.

(g) The general assembly hereby finds that preparation and provision of ~~diagnostic~~ academic growth information constitutes accountable education reform and may therefore be funded from moneys in the state education fund created in section 17 (4) of article IX of the state constitution.

(h) The department shall provide technical assistance and training to school districts and charter schools to assist school district and charter school personnel in interpreting and using the ~~diagnostic~~ academic growth information provided pursuant to this subsection (5). The costs of providing technical assistance and training pursuant to this paragraph (h) shall be paid BY THE DEPARTMENT within existing appropriations for implementation of this section.

(6) **Rule-making.** The state board is authorized to promulgate any rules necessary to calculate annual ~~diagnostic~~ LONGITUDINAL academic growth.

(7) **Academic growth information - research.** The department, upon request, shall make available to qualified researchers the entire longitudinally linked dataset created pursuant to this section and used for generating ~~diagnostic~~ ACADEMIC growth information and for awarding the

governor's distinguished improvement awards. For purposes of this subsection (7), qualified researchers shall include, but need not be limited to, institutions of higher education, school districts, and public policy research and advocacy organizations. The department shall provide the information in a format that allows it to be linked with other publicly available data in the state and shall include all available data regarding student demographics, the state's school identification numbers, and student-level performance data, while protecting the privacy of individual students in a manner consistent with the federal "Family Educational Rights and Privacy Act of 1974", 20 U.S.C. sec. 1232g, and all federal regulations and applicable guidelines adopted in accordance therewith.

SECTION 3. 22-11-305 (1), Colorado Revised Statutes, is amended to read:

22-11-305. Governor's distinguished improvement awards - repeal. (1) (a) The state board shall annually present financial awards to the public schools in the state demonstrating the highest rate of student academic growth. The technical advisory panel convened pursuant to section 22-7-604.3 (2) (b) shall recommend to the state board and the state board shall establish by rule the method by which to identify schools that demonstrate the highest rate of student academic growth in a school year toward state standards for proficiency. The technical advisory panel shall take school size into account in preparing its recommendations.

(b) (I) AS SOON AS PRACTICABLE AFTER THE ADOPTION OF THE MIXED-EFFECTS STATISTICAL MODEL PURSUANT TO 22-7-604.3 (3) (a), THE TECHNICAL ADVISORY PANEL SHALL RECOMMEND TO THE STATE BOARD AND THE STATE BOARD SHALL BY RULE ESTABLISH A NEW METHOD TO IDENTIFY SCHOOLS THAT DEMONSTRATE THE HIGHEST RATE OF ACADEMIC GROWTH BASED UPON THE MIXED-EFFECTS STATISTICAL MODEL. SUBJECT TO AVAILABLE APPROPRIATIONS, UNTIL THE ADOPTION OF RULES PURSUANT TO THIS SUBPARAGRAPH (I), THE DEPARTMENT SHALL CONTINUE TO PRESENT HONORARY OR FINANCIAL AWARDS PURSUANT TO THIS SECTION UNDER THE RULES EXISTING AS OF JANUARY 1, 2007.

(II) THIS PARAGRAPH (b) IS REPEALED, EFFECTIVE JULY 1, 2009.

SECTION 4. Repeal. 22-54-114 (2.5), Colorado Revised Statutes, is repealed as follows:

22-54-114. State public school fund. (2.5) ~~The general assembly finds that implementation of section 22-7-603.5, including implementation of rules to uniquely identify individual students, has resulted in more accurate determinations of pupil enrollment and a savings in the amount required to fund the state's share of total program funding for school districts and institute charter schools. For the 2003-04 budget year and budget years thereafter, the department of education shall allocate a portion of the amount of the in-year cost recovery occurring as a result of the use of unique student identifiers to fund implementation of section 22-7-604.3, concerning the calculation of academic growth of students for diagnostic purposes. The amount allocated for the implementation of section 22-7-604.3 shall not exceed two hundred thousand dollars in any budget year.~~

SECTION 5. Safety clause. The general assembly hereby finds,

determines, and declares that this act is necessary for the immediate preservation of the public peace, health, and safety.

Andrew Romanoff SPEAKER OF THE HOUSE OF REPRESENTATIVES	Joan Fitz-Gerald PRESIDENT OF THE SENATE
Marilyn Eddins CHIEF CLERK OF THE HOUSE OF REPRESENTATIVES	Karen Goldman SECRETARY OF THE SENATE

APPROVED_____

Bill Ritter
GOVERNOR OF THE STATE OF COLORADO

APPENDIX B
Technical Reports on Student Growth Percentiles

Attached

Estimation of Student Growth Percentiles for the Colorado Student Assessment Program: October 5, 2007

Available Electronically

Reference Growth Charts for Educational Outcomes: April 6th, 2007

Report to CDE Longitudinal TAP: June 12th, 2007

Presentation for Longitudinal TAP: August 22nd, 2007

Report to CDE Longitudinal TAP: October 12th, 2007
Examination of Goodness-of-Fit

Report to CDE Longitudinal TAP: October 12th, 2007
Defining a Year's Growth

Report to CDE Longitudinal TAP: November 16th, 2007
How Much is "Enough" Growth?

Report to CDE Longitudinal TAP: November 16th, 2007

Report to CDE Longitudinal TAP: November 16th, 2007
Confidence Intervals About School Level Summary Statistics

Report to CDE Longitudinal TAP: December 7th, 2007
Baseline versus Cohort Referenced Growth

Estimation of Student Growth Percentiles for the Colorado Student Assessment Program

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October 5, 2007

Abstract

Over the last decade the Colorado Department of Education has actively pursued research, implementation, and reporting of analyses that take advantage of longitudinal student CSAP data. Legislation enacted in 2004 (HB 04-1433) established growth analysis techniques currently employed by the Colorado Department of Education (CDE). Expanding this initiative, current legislation (HB 07-1048) has directed the Department of Education to refine/modify the current methodology to better assist schools in identifying students with rates of improvement deemed inadequate. The technical advisory panel (TAP) formed by CDE and tasked with recommending a model to the State Board of Education recently approved Student Growth Percentiles as the methodology/quantities best satisfying the requirements of the HB 07-1048 legislation. Following this recommendation, the TAP solicited Dr. Damian Betebenner from the The National Center for the Improvement of Educational Assessment to supply technical documentation sufficient for external review of the model/procedures used to derive student growth percentiles.

Policy Context

The legislative impetus for Colorado's current individual growth model, and Colorado's growth analyses in general, was HB 04-1433.[1] This bill directed the Colorado Department of Education to develop and implement a model capable of analyzing individual student growth and reporting the findings to schools. Following model specification in the Summer of 2004, the Colorado Department of Education pilot tested a growth model during the 2004-2005 school year based upon a mixed-effects design mandated by the legislation and discussed in detail in Betebenner & Doran (2004). After pilot testing and fine tuning of the model, using 2003, 2004 and 2005 CSAP data, school level student growth reports were generated and distributed to schools in the winter of 2005. Given no major problems with the model and the results, CSAP data up to the 2006 administration was analyzed in Fall 2006 with school level reports distributed soon thereafter.

Data provided by current growth analyses serve multiple purposes. Broadly, the analyses allow the State to determine an annual, individual specific, rate of growth and to use that quantity to predict future achievement (i.e., status) for individual students. The currently implemented growth analyses support the following:

[1] Colorado has also implemented a school level growth index reported on School Accountability Reports which won't be discussed in this report. See http://www.cde.state.co.us/cdeassess/documents/SAR/2005/Computing_academic_growth_of_students_how_to_final.doc for more information.

- Based upon a minimum of two years of data, for each student future achievement is estimated and determined to be at the unsatisfactory, partially proficient, proficient, or advanced level.
- Based upon these individual student achievement projections, aggregate percentages of students projected to be at each of the four performance levels by grade within school and school overall are computed.
- Using individual and aggregate statistics, school reports are generated and provided to schools containing as much forward looking information possible to schools.

The current model has been found to have shortcomings including:

- The model fits a linear growth trajectory to each student and uses that linear trend to predict future achievement. Longitudinal achievement for individual students across the vertical CSAP scale is not linear and, for most students, displays a negative concavity. The use of a linear trend for each student results in higher predicted achievement than is likely to occur.
- HB 04-1433 specified that the results of the model be used to bestow Governor's Distinguished Improvement Awards to schools demonstrating outstanding student growth. The TAG recognized that the percentage of students projected to be proficient was strongly correlated with current school level achievement/status measures (i.e., percent of students proficient) and likely confounded growth of students at a given school with their initial status.
- Results recently reported by a district suggest that proper model identification requires a minimum of three time points for analysis. With such a requirement, the soonest individual achievement projections would be available is after students complete the grade 5 CSAP test—that is, after most students leave elementary school.

Given the positive benefits of providing longitudinal data coupled with diagnostic/prognostic information about current/future achievement and growth of students, the previous TAG felt the positives significantly outweighed the shortcomings and followed through on the analyses using the mixed effects growth model specified in Betebenner & Doran (2004). In line with the initiative begun with HB 04-1433, HB 07-1048 (see Page 35 for the complete text of the legislation) asks the department to continue pursuing the goal of making growth analyses an integral part of the accountability system in Colorado.

HB 07-1048 stipulates a number of requirements for the growth model/analyses developed by the Colorado Department of Education. The growth model implemented by the state should

- provide diagnostic information to support improving students' academic achievement and the closing of the achievement gap.
- indicate how many and which students make at least a year's growth in a year's time.
- identify how many and which students are on pace to reach various proficiency standards in the next three years, or by grade 10.
- produce student-level and school-level reports.
- support an accountability system that "encourages and supports teachers in meeting the needs of all students"

With differing degrees of success, Colorado's current growth model fulfills points 1, 3, 4, and 5. Moreover, the current model addresses point 2 to the extent that it defines a year's growth to be the scale score change necessary, based upon a linear projection, for the individual student to reach the proficiency threshold in three years (or by grade 10, whichever comes sooner). In this sense, the current model presents a dichotomous measure based upon the state's performance standards of whether a student is making adequate progress.

HB 07-1048 asks the Colorado Department of Education to refine the current methodology and return to the first and most fundamental directive asked by policy makers nationwide with regard to longitudinal student achievement: Determine whether a student has made a year's growth. Providing an answer to that directive beyond that already supplied by the current HB 04-1433 growth-to-standard methodology would be a fundamental step in providing parents, teachers, principals, and policy makers with insight into the performance of individual students, schools, districts, and the state overall. The following discussion refines the analysis techniques developed by the state of Colorado over the past three years to fulfill the mandates set out in HB 07-1048.

Modeling Growth under HB 07-1048

Growth analyses and, more broadly, longitudinal data analysis, are currently used nationwide for diverse purposes with regard to the analysis of student assessment data. The primary thrust of growth analyses over the last decade has been to use prior student achievement to disentangle current aggregate level achievement from effectiveness (Braun, 2005; Ballou, Sanders, & Wright, 2004) The TVAAS/EVAAS value-added analyses developed by Dr. William Sanders represent the best known and one of the most sophisticated attempts to use prior student achievement to quantify effectiveness at the teacher and school level (Sanders, Saxton, & Horn, 1997). These models have gained tremendous notoriety, so much so that the entire Spring 2004 issue of the Journal of Educational and Behavioral Statistic was devoted to the topic. Assuming that student background characteristics can be completely accounted for, the benefit to measures of school or teacher quality is clear: effectiveness is distinguished from achievement so that excellent (i.e., highly effective) schools serving low, average and high achieving students can be identified.

Though based upon individual, longitudinal data, models suitable for quantifying school or teacher effectiveness are generally not well suited for making individual determinations concerning student progress (Betebenner, 2004). Close examination of HB 07-1048 and its aforementioned goals indicate that the State of Colorado is primarily interested in a means of quantifying/describing student growth and secondarily interested in aggregate quantifications of "effectiveness" that can be used to bestow the Governor's Distinguished Improvement Awards. To this end, borrowing ideas from pediatrics used to inform parents about the height/weight of their children over time(Wei & He, 2006; Wei, Pere, Koenker, & He, 2006; Cole, 1994; Cole, 1988), *student growth percentiles* were proposed by Dr. Damian Betebenner to the technical advisory panel (TAP) as a means of describing rates of student growth. Just as achievement percentiles relate how a student's achievement compares to others, growth percentiles relate how a student's growth compares to others. Using a student's prior achievement, a student growth percentile normatively quantifies a student's growth. Determinations of the *adequacy* of growth, like determinations of the adequacy of achievement, are investigated separately *vis-á-vis* a standard setting procedure.

Student Growth Percentile Estimation

Calculation of a student's growth percentile is based upon the estimation of the conditional density associated with a student's score at time t using the student's prior scores at times $1, 2, \ldots, t-1$ as the conditioning variables. Given the conditional density for the student's score at time t, the

student's growth percentile is defined as the percentile of the score within the time t conditional density. By examining a student's current achievement with regard to the conditional density, the student's growth percentile normatively situates the student's outcome at time t taking account of past student performance. Given that the result is in the percentile scale, the quantity reflects the likelihood of such an outcome given the student's prior achievement. In the sense that the student growth percentile (specifically, SGP/100) quantifies the probability of such an outcome, in terms of the frequency of an event occurring (i.e., rarity), it is possible to compare the progress of individuals not beginning at the same starting point. However, occurrences being equally rare does not necessarily imply that they are equally "good". Qualifying a student's growth percentile as "(in)adequate", "good", or as satisfying "a year's growth" is a standard setting procedure requiring external criteria (e.g., growth relative to state performance standards) and the combined wisdom/judgments of stakeholders.

Estimation of the conditional density is performed using quantile regression (Koenker, 2005). Whereas linear regression methods model the conditional mean of a response variable Y , quantile regression is more generally concerned with the estimation of the family of conditional quantiles of Y. Quantile regression provides a more complete picture of both the conditional distribution associated with the response variable(s). The techniques are ideally suited for estimation of the family of conditional quantile functions (i.e., reference percentile curves). 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. Position of the student's most recent score within this density can then be used to qualify deficient/sufficient/excellent growth. Though CSAP assessment possess a vertical scale, such a scale is not necessary to produce student growth percentiles.

In analogous fashion to the least squares regression line representing the solution to a minimization problem involving squared deviations, quantile regression functions represent the solution to the optimization of a loss function (Koenker, 2005, p. 5). Formally, given a class of suitably smooth functions, $\mathcal{G}$, one wishes to solve

$$\arg\min_{g\in\mathcal{G}} \sum_{i=1}^{n} \rho_\tau(Y(t_i) - g(t_i)), \tag{1}$$

where t_i indexes time, Y are the time dependent measurements, and ρ_τ denotes the piecewise linear loss function defined by

$$\rho_\tau(u) = u \cdot (\tau - I(u < 0)) = \begin{cases} \tau u & u \geq 0 \\ (\tau - 1)u & u < 0. \end{cases}$$

The elegance of the quantile regression Expression 1 can be seen by considering the more familiar least squares estimators. For example, calculation of $\arg\min \sum_{i=1}^{n}(Y_i - \mu)^2$ over $\mu \in \mathbb{R}$ yields the sample mean. Similarly, if $\mu(x) = x'\beta$ is the conditional mean represented as a linear combination of the components of x, calculation of $\arg\min \sum_{i=1}^{n}(Y_i - x_i'\beta)^2$ over $\beta \in \mathbb{R}^p$ gives the familiar least squares regression line. Analogously, when the class of candidate functions $\mathcal{G}$ consists solely of constant functions, the estimation of Expression 1 gives the τth sample quantile associated with Y. By conditioning on a covariate x, the τth conditional quantile function, $Q_y(\tau|x)$, is given by

$$Q_y(\tau|x) = \arg\min_{\beta\in\mathbb{R}^p} \sum_{i=1}^{n} \rho_\tau(y_i - x_i'\beta).$$

In particular, if $\tau = 0.5$, then the estimated conditional quantile line is the median regression line.[2]

[2]For a detailed treatment of the procedures involved in solving the optimization problem associated with Expres-

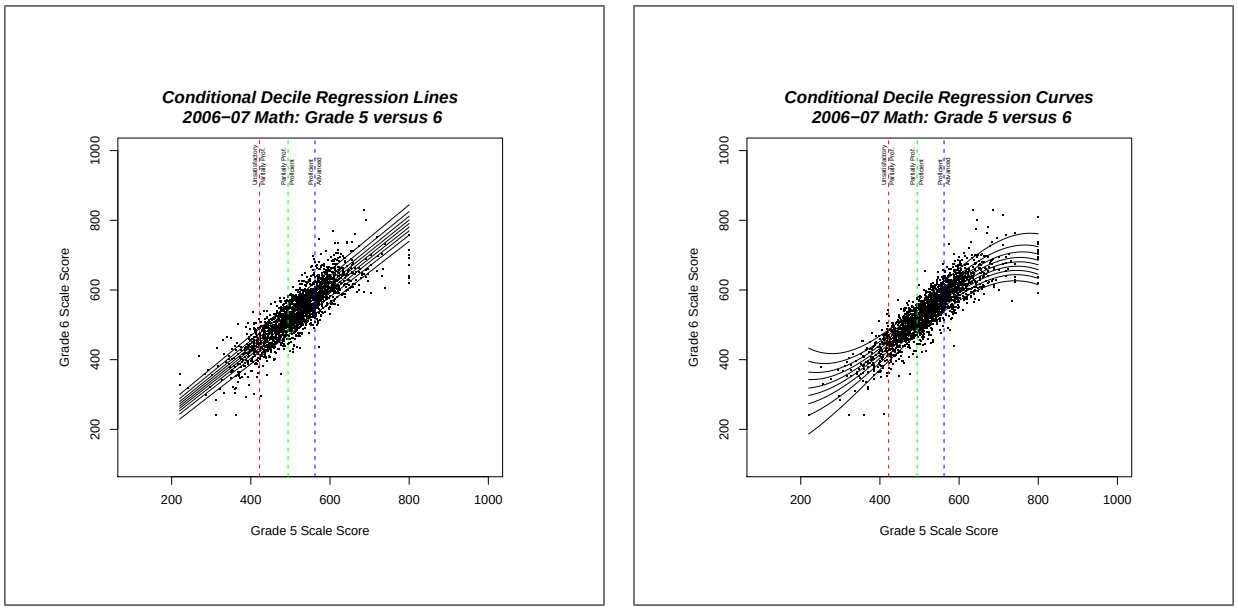

Figure 1: Linear and B-spline conditional deciles based upon bi-variate CSAP math data, grades 5 and 6

Following Wei & He (2006), we parameterize the conditional quantile functions as a linear combinations of B-spline cubic basis functions.. B-splines are employed to accommodate heteroscedasticity and skewness of the conditional densities associated with values of the independent variable(s). Using B-splines is attractive both theoretically and computationally in that they provide excellent data fit, seldom lead to estimation problems (Harrell, 2001, p. 20), and are simple to implement in available software. As will be seen when examining goodness-of-fit, use of B-splines instead of linear percentile curves leads to appreciable improvement in goodness-of-fit over the more common linear parameterization of the conditional percentile functions.

Figure 1 gives a bivariate representation of linear and B-splines parameterization of decile growth curves. The assumption of linearity imposes conditions upon the heteroscedasticity of the conditional densities. Close examination of the linear deciles indicates slightly greater variability for higher grade 5 scale scores than for lower scores. By contrast, the B-spline based decile functions more accurately represent greater variability at both ends of the scale score range together with a slight, non-linear trend to the data.

Currently, calculation of student growth percentiles is performed using R, a language/environment for statistical computing, with Koenker's `quantreg` package (R Development Core Team, 2006). Other possible software (untested with regard to student growth percentiles) with quantile regression capabability include SAS and Stata. Estimation of the student growth percentiles is conducted using all available prior data, subject to certain suitability conditions. Given CSAP assessment scores for t occasions, $(t \geq 2)$, the τ-th conditional quantile for Y_t based upon $Y_{t-1}, Y_{t-2}, \ldots, Y_1$ is given by

$$Q_{Y_t}(\tau|Y_{t-1}, \ldots, Y_1) = \sum_{j=1}^{t-1} \sum_{i=1}^{3} \phi_{ij}(Y_j)\beta_{ij}(\tau) \tag{2}$$

where $\phi_{i,j}$, $i = 1, 2, 3$ and $j = 1, \ldots, t-1$ denote the B-spline basis functions. Currently, bases consisting of 3 cubic polynomials are used to "smooth" irregularities found in the multivariate assessment data. A bivariate rendering of this is found is Figure 1 where linear and B-spline conditional

sion 1, see Koenker (2005), particularly Chapter 6.

deciles are presented. The cubic polynomial B-spline basis functions model the heteroscedasticity and non-linearity of the data to a greater extent than is possible using a linear parameterization.

Given multivariate normal assessment data, calculation of student growth percentiles is approximately equivalent to conversion of linear regression based least squares residuals to percentiles. Even in situations without multivariate normality, residual derived percentiles yield rough approximations to the student growth percentiles calculated using more robust quantile regression estimation techniques.[3] Whereas the majority of longitudinal analysis techniques using student assessment data seek to *explain* this residual variability *vis-á-vis* teacher or school effects, the primary concern with calculating student growth percentiles is to *describe* this variability and, following similar descriptions used in pediatrics, give stakeholders a sense of what the current range of growth in student achievement is.[4]

Discussion of Model Properties

Student growth percentiles possess a number of attractive properties from both a theoretical as well as a practical perspective. Foremost among practical considerations is that the percentile descriptions are familiar and easily communicated to teachers and other stakeholders. Furthermore, implicit within the percentile quantification of student growth is statement of probability. Questions of "how much growth is enough?" or "how much is a year's growth?" ask stakeholders to establish growth percentile thresholds deemed adequate. These thresholds establish growth standards that translate to probability statements. Percentiles based growth standards are essential to the establishment of rigorous yet attainable growth standards for all children. Broadly, student growth percentiles provide a normative context to apply Linn's (2003) existence proof to student growth at the individual level.

In addition to practical utility, student growth percentiles possess a number of technical attributes well suited for use with assessment scores. The more important theoretical properties of growth percentiles include:

Robustness to outliers Estimation of student growth percentiles are more robust to outliers than is traditionally the case with conditional mean estimation. Analogous to the property of the median being less influenced by outliers than is the median, conditional quantiles are robust to extreme observations. This is due to the fact that influence of a point on the τ-th conditional quantile function is not proportional (as is the case with the mean) to the distance of the point from the quantile function but only to its position above or below the function (Koenker, 2005, p. 44).

Student growth percentiles are uncorrelated with prior achievement Analogous to least squares based residuals being uncorrelated with independent variables, student growth percentiles are not correlated with prior achievement. This property overcomes a shortcoming of the current multilevel approach to measuring growth with testing occassion nested within students. This approach, exploiting the vertical CSAP reading and math scales, fits lines with distinct slopes and intercepts to each student. The slopes of these lines represent an "average" rate of increase for the student across measurement occasions. Not surprisingly, these rates demonstrate regression toward artifacts with lower achieving students generally increasing at rates exceeding those of their high achieving counterparts (Marsh & Hau, 2002).

[3] Percentiles derived from least squares residuals demonstrate large bias in a large number of cases. This issue will be addressed more fully in the goodness-of-fit section on Page 10.

[4] See http://www.nutropin.com/patient/3_5_4_growth_velocity.jsp for an online implementation of pediatric growth percentiles associated with height.

With regard to student growth percentiles being uncorrelated with status, it is important to fully understand a normative quantification of growth. One can not validly infer that a low achieving student with a growth percentile of 60 "learned as much" as a high achieving student with the same growth percentile. Growth percentiles bypass questions associated with magnitude of learning and focus on normatively quantifying changes in achievement. It is instructive to note that even in fields with perfect measurement scales, absolute measures of change rarely provide meaningful information. A pediatrician can tell a parent exactly how much their child has grown since their last check up. That quantity (e.g., 4 inches) is well understood in terms of magnitude, yet almost meaningless in and of itself. Only when that change is situated relative to others does it take on its fuller meaning.

Equivariance to monotone scale transformation The most important attribute of the quantile regression methodology used to calculate student growth percentiles is their invariance to monotone transformations of scale. This property, denoted by Koenker (2005) as *equivariance to monotone transformations* is particularly helpful in educational assessment where a variety of scales are present for analysis, most of which are related by some monotone transformation. For example, it is a common misconception that one needs a vertical scale in order to calculate growth. Because vertical and non-vertical scales are related via a monotone transformation, the student growth percentiles do not change given such alterations in the underlying scale. This result obviates much of the discussion concerning the need for a vertical scale in measuring growth.[5]

Formally, given a monotone transformation h of a random variable Y,

$$Q_{h(Y)|X}(\tau|X) = h(Q_{Y|X}(\tau|X)).$$

This result follows from the fact that $\Pr(T < t|X) = \Pr(h(T) < h(t)|X)$ for monotone h. It is important to note that equivariance to monotone transformation does not, in general, hold with regard to least squares estimation of the conditional mean. That is, except for affine transformations h, $E(h(Y)|X) \neq h(E(Y|X))$. Thus, analyses built upon mean based regression methods are, to an extent, scale dependent.

Missing/Incomplete Data

As with any analysis of large scale observational data, missing or incomplete data is an issue. Calculation of the student growth percentile corresponding, for example, with a student's 2007 CSAP score, is based upon estimation of a conditional density. Because the purpose is to describe growth in the most recent year, at a minimum, it is necessary to have the student's prior year's score to condition upon. Because the conditional distribution is derived based upon the observations of thousands of other students in the state population, operational decisions are made that define which student scores are part of the norming population and which are not:

- Students must have at a minimum two CSAP scores coming from consecutive years and grades (e.g., grade 4 in 2006 and grade 5 in 2007).

[5] As already noted with regard to pediatrics, the existence of nice "vertical" scales for measuring height and weight still leads to observed changes being normed.

- Only CSAP data from consecutive grades is used to estimate the conditional density for a student. Students repeating/skipping grades associated with the latest score (i.e., the dependent variable of 2) are not included in the analyses at this time.[6]

- Only CSAP data from consecutive years is used to estimate the conditional density for a student. For example, given a student possessing 2004, 2006, and 2007 CSAP reading data, only scale scores from 2006 and 2007 are used to calculate their student growth percentile. The number of students with such "holes" in their data is extremely small (less than 1%). Moreover, examination of students with complete data indicates that even though the inclusion of prior scores can lead to different student growth percentiles, growth percentiles based upon fewer prior scores are unbiased with regard to those derived using the maximum possible prior scores.

- Operationally, students with two CSAP scores in consecutive grades and years receive a student growth percentile conditioning upon the single prior score; students with three CSAP scores in consecutive grades/years receive a student growth percentile conditioning upon the prior two scores; students with four CSAP scores in consecutive grades/years receive a student growth percentile conditioning upon the prior three scores; and so on. After all possible growth percentiles are calculated for students, following HB 07-1048 stipulations, the growth percentile based upon the maximum prior data is assigned to the student. Thus, students with exactly two consecutive CSAP scores are compared with all other students with *at least* 2 scores; student with exactly 3 consecutive CSAP scores are compared with all other students with *at least* 3 scores; and so on. Student growth percentiles are normed relative to all student possessing scores on the same test as the student.

The above definitions lead to the estimation of student growth percentiles for more than 97% of the students in the Colorado State Assessment Program with 2 or more scale scores.

Accuracy and Precision of Student Growth Percentiles

As with all statistical procedures, the accuracy and precision of student growth percentiles is dependent upon a number of factors including models assumptions, sparcity of data at the scale extremes, and measurement error. The importance of precision is directly related to the inferences one wishes to draw from the growth percentiles. As with achievement comparison using scale scores, fine grained comparisons using growth percentiles cannot be sustained. Definitive statements to the effect that a student with a growth percentile 5 points higher than another student's demonstrates "superior growth" are not possible. However, like with pediatrics, it's possible to use the normative data to define regions of growth percentiles representing, for example, problem, average, and superior growth. Judgments concerning thresholds between the regions can be made based upon statistical as well as practical information, especially information about what growth percentiles are necessary to reach standards based achievement targets.

To investigate precision, a set of analyses was conducted that compared scale score differences related to 75th-20th percent growth and 75th-50th percentile growth to understand both the magnitudes of such differences across the range of prior achievement and its relation to the conditional standard error of measurement for the exam. Figure 2 uses growth percentiles for 2006 grade 10 math to examine scale score difference across the range of prior grade 9 math achievement in 2005.

[6] In theory, the vertical scale allows for treating a scale score on a CSAP examination as "equivalent" to the scale score a student would receive on another grade's exam. Because such students are a minor percentage of the overall number of students, we leave untested the examination of that hypothesis and exclude these students from the norming population.

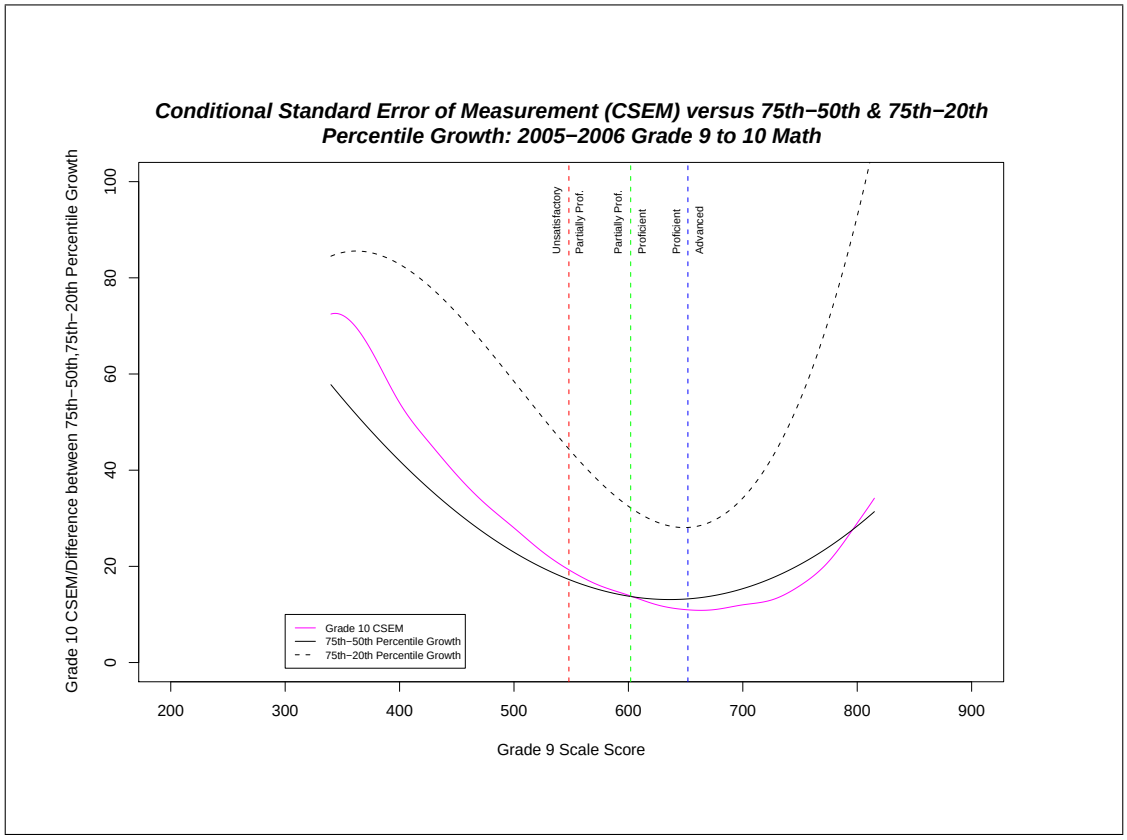

Figure 2: Scale score difference associated with 20th, 50th, and 75th percentiles relative to the CSEM for 2006 grade 10 math

The results of Figure 2 suggest that at the scale score extremes, error in measurement exceed scale score differences associated with 75th-50th percentile growth but does not exceed 75th-20th percentile scale score differences.[7] Placing growth on the percentile metric appears to supply great enough precision for coarse judgements at the individual level. For example, a deficient/average/superior trichotomy appears defensible. Of course, aggregation of student growth percentiles, as with any statistic, provides greater precision and the possibility for finer distinctions to be made.

Following requirements of HB 07-1048, the TAP is presently considering percentile thresholds to be used in making determinations of whether a student has made "a year's growth" and whether their growth is sufficient with respect to reaching/maintaining proficiency. If individual qualifications are to be made based upon those thresholds, then consideration must be given to precision and the possibility of misclassification. With no individual consequences, the possibility of misclassification has minor importance. As individual consequences emerge (e.g., individual student review or intensive remediation) based upon deficient growth percentiles, careful consideration of the consequences associated with growth percentile precision must be considered. The practical issues will be investigated as part of CDE's growth model development.

Model Performance using CSAP Data

This section complements the theoretical presentation of the model with a brief overview of some basic descriptive results thus far investigated with student growth percentiles on the latest available

[7] Results for other subjects and other grades demonstrate similar overall patterns.

2007 CSAP data in reading, writing, and mathematics. Most important in these investigations is the goodness-of-fit of the quantile regression estimated growth percentiles. In addition to goodness-of-fit analyses, descriptive results are presented with regard to student gender and ethnicity.

Goodness-of-Fit

Examination of goodness-of-fit was conducted by examining the estimated conditional density against the theoretical density. Despite the use of B-splines to accommodate heteroscedasticity and skewness of the conditional density, assumptions are made concerning the number and position of spline knots that impact the percentile curves that are fit. With an infinite CSAP population, at each prior scale score, with perfect model fit, the expectation is to have 10 percent of the estimated growth percentiles between 0 and 9, 10 and 19, 20 and 29, ..., and 90 and 99. Deviations from 10 percent would be indicative of lack of model fit. To motivate the extent to which lack of fit might contaminate student growth percentiles, student growth percentiles are also calculated using a linear parameterization in addition to B-splines. Though the maximum number of prior were used to calculate the student growth percentiles, the result of linear versus B-spline estimation is roughly what is depicted in the bivariate scatterplots of Figure 1

Using 2007 math, reading, and writing scores as the dependent variable, estimation of student growth percentiles was conducted exactly as outlined previously using the maximum number of consecutive year by grade CSAP scores for each student. Percentages of student growth percentiles at the 10th, 20th, 30th, 40th, 50th, 60th, 70th, 80th, and 90th percentiles were calculated based upon the decile of the prior year's scale score (each decile consists of approximately 5,000 students). Results for the B-spline and linear parameterizations for math, reading and writing are given in Tables 1 to 6 (pages 13 to 18).

Beginning with the growth percentiles derived using linear percentile curves (Tables 4 to 6), the results indicate, not surprisingly, rather poor fit in the highest and lowest prior scale score deciles. For example, in 2007 grade 4 math (Table 4), 21.82% of the estimated student growth percentiles were less than 10 for the lowest 2006 achievement decile of students. The result indicates model bias against low achieving students in grade 4 math. Similarly, 23.94% of the estimated student growth percentiles were less than 10 for the highest 2006 achievement decile of students. As with the low achievers in grade 4 math, the linear parameterization yields biased growth percentiles for high achieving students.

Contrasting the linear results with the B-spline results shows the impact that smoothing has on goodness-of-fit. Using the same 2007 grade 4 math data, the B-spline derived student growth percentiles yielded 11.57% and 11.93% of growth percentiles less than 10 for the lowest and highest 2006 achievers, respectively. Though slightly biased, the results are appreciably better than those derived from the linear model. Across all 2006 achievement deciles, grades, and subjects, the B-spline derived percentiles performed very well. Absolute deviations from expectation are generally quite small (less than 1.5 percent) with the largest absolute deviation just less than 4. By contrast, the results based upon the linear model can differ markedly from expected and would not be suitable for reporting purposes. Dependending upon the opinion of the technical review and the TAP, additional smoothing can be investigated to try and improve fit even further.

Descriptive Growth Percentile Results

Given the performance with regard to goodness-of-fit, this section presents summary 2007 CSAP student growth percentile results by ethnicity and gender. Because of the non-interval nature of the percentile metric, it is necessary to summarize percentiles in ways other than the arithmetic mean. For purposes of this discussion, boxplots associated with student growth percentiles are reported by

ethnicity (Figures 3 to 9, pages 20 to 26) and gender (Figures 10 to 16, pages 28 to 34 for each grade and subject. Median growth percentiles by subgroup represent the percentile for which 50% of the group are above and 50% below. Assuming random assignment of students to subgroup, the expected median growth percentile is 50. That is, the expectation is that 50% of students will be above the state normed 50th growth percentile and 50% will be below.[8] Median growth percentiles above (below) 50 represent group performance better (worse) than expected.

Across all grades and subjects, the growth percentile results for ethnicity are consistent: Asians are the group demonstrating the best performance with regard to student growth percentiles, followed by whites, with African American, Hispanic, and Native American groups having median growth percentiles below 50. In most grades and subjects, the median growth percentile for Asians approaches or exceeds 60. These results complement achievement gap results already reported for the state that form the basis for NCLB based accountability systems. The results indicate that mandates to close achievement gaps must first reach an intermediate point where achievement gaps (tracked longitudinally) do not get any larger.

Growth percentile results across grades and subject by gender present differences as well (see Figures 10 to 16, pages 28 to 34). In writing, females consistently outperform their male counterparts. Whereas in reading and math, the results usually either reflect parity or a slight advantage for females. Differences, of course, do not indicate cause, and numerous factors might possibly impact state growth percentile results by ethnicity and gender. If growth percentiles become a useful descriptive quantity, then questions concerning cause/responsibility will almost certainly follow.

Summary

This paper has introduced student growth percentiles and the quantile regression analysis techniques used for their calculation. The Colorado Department of Education is considering student growth percentiles and the associated methodology as a means of fulfilling recently enacted legislation (HB 07-1048) directing the Department to develop and implement a growth model. Given these guidelines, the purpose of developing these percentiles is to provide educational stakeholders at various levels (students, parents, teachers, principals, administrators, and policy makers) a simple yet rigorous means by which to understand student progress given the vast amounts of longitudinal data currently available.

Calculated using the estimated conditional density associated with a student's prior achievement, student growth percentiles provide a normative quantification of growth that allows for comparison of growth rates in terms of frequency. Given this normative foundation, student growth percentiles can be used within a standard setting procedure to define what is "enough growth" or "a year's growth". The technical advisory panel is currently considering different standards that can be used to define "a year's growth".

Performance of the quantities with regard to goodness-of-fit analyses is excellent, indicating that the student growth percentiles are accurate descriptions of student progress. Preliminary descriptive results support the contention that the growth percentiles are not biased. Aggregation of the growth percentiles using either the median or percent above threshold presents a summary measure of student growth for the aggregation unit that is informative and does not necessarily lead toward strong inferences about effectiveness and underlying causality. In the coming months, more research will be conducted to refine and validate student growth percentiles and their underlying methodology.

[8] Dependending upon TAP decisions concerning a year's growth criterion, percentages of students demonstrating a year's growth is represents another possible group measure.

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Supplementary Tables

The following tables present percentages of 2007 student growth percentiles at or below 10, 20, 30, 40, 50, 60, 70, 80, and 90 based upon the 2006 scale score decile of the student. Given adequate model fit, one would expect a uniform distribution of growth percentiles across the prior score distribution and for there to be $n\%$ of the observed percentiles to lie at or below n. Deviations suggest a model parameterization that doesn't adequately fit the data. Such deviations can be seen in the results associated with a linear parameterization given in Tables 5 through 6. The B-spline parameterization results in much better fit (Tables 1 to 3).

2006 Grade	2006 SS Decile	Observed Percentages of SGP at or below Given Percentile								
		10th	20th	30th	40th	50th	60th	70th	80th	90th
3	1	11.57	21.50	31.95	42.28	52.07	61.52	71.52	81.33	90.97
3	2	11.15	21.46	31.29	41.22	51.49	61.68	71.25	80.91	90.64
3	3	10.98	20.61	30.49	40.45	50.01	60.48	70.68	80.52	90.88
3	4	10.60	21.37	31.50	41.79	51.46	61.28	71.15	81.83	91.59
3	5	10.99	20.65	30.51	39.82	50.15	59.98	70.05	80.76	91.37
3	6	10.06	20.06	29.62	39.79	50.69	61.13	71.30	81.15	91.59
3	7	10.80	20.60	30.53	40.01	50.08	60.42	71.11	80.95	90.69
3	8	10.91	20.50	30.00	39.88	49.38	59.27	69.84	80.12	90.30
3	9	11.07	21.07	31.91	42.63	52.64	62.49	71.53	81.06	90.70
3	10	11.93	22.10	32.26	42.14	52.04	61.79	71.48	81.40	91.26
4	1	10.96	20.63	30.70	40.48	50.27	60.20	69.89	79.98	90.06
4	2	10.99	21.23	32.05	41.60	51.48	61.19	70.32	80.07	90.45
4	3	11.53	21.37	30.84	40.61	50.75	60.50	71.10	81.08	90.57
4	4	11.58	22.12	31.75	42.50	52.12	61.41	72.01	81.57	91.71
4	5	11.13	21.52	31.50	41.59	51.30	61.22	71.52	80.81	91.42
4	6	10.53	19.81	30.08	39.83	50.55	61.43	71.04	81.85	90.85
4	7	10.73	21.29	31.04	41.24	50.64	60.75	70.64	81.01	91.10
4	8	10.41	19.84	30.53	40.17	50.60	60.48	70.31	80.19	90.75
4	9	11.03	20.95	30.10	40.28	49.85	60.11	70.52	80.71	90.83
4	10	11.37	21.43	31.96	41.70	51.76	61.60	71.42	81.16	90.82
5	1	11.25	21.27	30.78	40.18	49.86	59.39	69.10	79.14	90.25
5	2	10.86	19.94	29.31	39.29	48.58	58.78	69.26	80.27	90.12
5	3	10.37	20.05	29.60	39.90	50.29	60.44	70.51	80.62	90.77
5	4	10.53	21.33	32.52	42.78	53.34	63.41	73.08	82.32	91.78
5	5	12.35	23.14	33.73	44.15	53.88	64.08	73.99	83.11	91.51
5	6	12.04	22.35	32.47	42.97	52.95	62.62	72.07	81.99	91.58
5	7	11.75	22.58	32.85	42.57	52.36	62.57	72.18	81.63	91.11
5	8	10.42	19.45	29.54	38.93	49.37	58.77	69.58	79.62	90.86
5	9	10.03	19.84	28.30	37.92	47.79	58.32	68.56	79.38	90.44
5	10	11.07	21.29	31.62	41.94	51.71	61.53	71.32	81.13	90.67
6	1	10.98	20.10	29.01	38.68	48.53	58.40	68.85	79.36	90.67
6	2	10.09	19.49	29.58	39.38	48.76	58.74	69.28	79.52	89.64
6	3	10.78	21.00	30.72	41.25	51.80	62.38	72.05	82.10	91.42
6	4	10.93	21.43	32.14	42.83	52.97	62.56	72.41	81.66	91.21
6	5	12.24	22.92	33.18	43.39	53.38	63.15	72.68	82.27	91.59
6	6	12.56	24.10	34.63	44.41	54.08	63.41	73.25	82.91	92.17
6	7	11.19	22.02	32.53	42.40	52.55	62.89	72.60	82.11	91.54
6	8	11.50	21.57	31.04	40.78	51.12	61.01	70.56	80.36	90.59
6	9	9.57	17.75	26.77	36.64	46.47	56.68	67.64	78.72	89.77
6	10	10.44	19.75	29.61	39.53	49.45	59.49	69.74	80.02	90.46
7	1	10.99	21.00	30.95	40.58	50.51	59.77	69.57	79.77	90.01
7	2	11.06	20.79	30.46	40.00	49.89	60.01	70.31	79.97	90.17
7	3	10.62	20.27	29.86	39.98	49.57	59.65	69.71	80.33	91.43
7	4	11.13	21.07	31.13	41.25	51.44	62.00	71.42	81.31	91.21
7	5	11.81	21.87	31.99	41.76	51.80	62.21	72.49	82.24	91.07
7	6	11.26	21.61	32.36	42.96	53.09	62.89	72.49	81.62	91.10
7	7	11.34	21.78	31.56	42.02	52.33	62.46	72.18	81.65	91.21
7	8	11.19	21.30	31.42	41.38	50.61	60.67	70.75	80.92	90.44
7	9	10.68	20.22	29.69	38.77	48.84	57.64	68.13	78.68	89.78
7	10	10.49	20.09	29.73	39.89	50.01	60.39	70.14	80.50	91.15
8	1	12.75	21.56	30.69	40.68	50.42	60.27	69.20	80.35	90.28
8	2	10.93	20.84	31.39	41.22	51.33	61.46	70.97	81.41	90.91
8	3	11.24	21.39	31.26	41.96	52.15	61.73	70.78	81.37	91.31
8	4	11.97	23.00	33.66	43.79	52.93	62.96	71.65	81.89	90.88
8	5	11.30	21.88	32.05	42.39	52.28	61.75	71.08	82.19	91.97
8	6	11.01	21.47	30.83	39.94	51.12	61.68	70.70	81.34	91.08
8	7	10.42	20.62	31.02	40.96	50.92	61.13	69.91	80.92	91.02
8	8	10.88	20.65	30.15	40.30	49.87	59.94	69.20	79.89	90.34
8	9	11.33	20.45	30.28	40.74	50.75	60.35	69.41	80.49	90.49
8	10	11.00	20.51	30.07	39.85	49.75	59.65	69.15	79.89	90.33
9	1	12.54	22.16	31.01	40.19	49.68	59.69	69.96	80.32	90.37
9	2	11.01	21.03	30.30	40.34	50.67	60.10	70.89	80.59	90.75
9	3	11.65	21.98	32.46	42.99	52.64	62.59	72.46	82.03	91.40
9	4	10.98	20.91	31.89	41.60	51.76	61.74	69.97	79.69	90.24
9	5	9.97	20.51	30.62	40.36	49.77	59.53	70.05	80.34	90.13
9	6	10.56	20.64	30.73	40.93	50.13	59.69	70.29	80.06	90.30
9	7	10.84	20.41	29.91	39.49	49.35	59.50	69.24	80.15	90.28
9	8	10.44	19.72	29.50	39.81	50.56	60.23	70.42	80.74	90.80
9	9	12.09	22.13	31.50	41.29	51.31	61.19	71.74	81.17	91.02
9	10	10.89	20.26	30.02	39.75	49.72	59.73	69.77	79.98	90.76

Table 1: Decile by grade examination of goodness-of-fit for 2007 CSAP math student growth percentiles using B-spline smoothing

2006 Grade	2006 SS Decile	Observed Percentages of SGP at or below Given Percentile								
		10th	20th	30th	40th	50th	60th	70th	80th	90th
3	1	11.63	21.61	30.97	40.46	50.17	59.72	68.66	78.80	89.59
3	2	10.90	20.96	31.94	42.33	52.62	62.53	72.82	82.57	92.28
3	3	10.48	20.89	31.23	41.64	52.32	62.43	72.91	83.40	92.18
3	4	11.37	22.16	32.04	41.96	51.69	62.50	73.16	82.98	92.09
3	5	10.23	19.95	30.62	41.86	52.22	63.06	73.35	82.84	91.94
3	6	11.33	20.38	30.13	40.03	50.08	60.09	70.20	80.25	90.78
3	7	10.70	19.87	29.82	39.60	49.65	59.19	69.38	79.66	90.24
3	8	10.52	20.11	29.35	38.97	48.80	58.47	68.53	78.70	89.96
3	9	11.43	21.99	31.32	40.54	49.97	59.98	69.63	79.36	89.72
3	10	11.55	21.98	32.56	42.71	52.63	62.21	71.59	81.62	91.32
4	1	10.94	20.70	30.41	39.86	49.70	59.19	69.05	78.79	89.25
4	2	11.03	20.85	31.50	41.44	51.41	61.45	71.84	81.78	91.71
4	3	12.08	22.50	32.14	42.19	52.57	63.26	73.21	83.18	92.26
4	4	10.25	20.53	31.86	42.34	53.29	63.07	72.60	82.77	92.10
4	5	11.67	21.74	31.87	42.03	52.10	62.00	71.88	81.64	91.71
4	6	10.81	20.84	30.15	40.67	50.29	60.75	70.06	80.31	90.30
4	7	11.31	20.81	30.20	39.89	49.33	59.25	69.36	79.41	89.91
4	8	10.38	20.14	30.02	39.38	49.64	59.11	69.20	79.41	90.26
4	9	10.73	20.05	29.79	39.26	48.93	58.94	69.34	79.59	90.30
4	10	11.32	21.98	31.64	41.98	51.99	61.93	71.70	81.89	91.35
5	1	12.18	21.72	31.62	41.63	51.69	61.43	70.94	80.22	89.70
5	2	9.86	19.52	29.40	39.10	49.15	59.02	69.35	80.14	91.31
5	3	10.06	20.18	30.90	40.74	50.36	60.55	70.57	81.04	91.29
5	4	10.73	22.23	32.43	42.02	52.06	62.15	72.41	82.78	92.12
5	5	10.37	19.77	29.95	40.01	50.81	60.87	71.15	80.69	90.99
5	6	11.83	21.34	31.26	41.41	52.21	62.13	71.92	81.59	91.16
5	7	11.26	20.94	31.47	41.46	51.15	61.44	71.20	81.27	90.74
5	8	11.66	20.98	30.64	40.71	50.48	60.43	69.95	79.35	90.07
5	9	11.73	21.42	30.58	40.57	49.79	58.77	68.74	78.48	89.52
5	10	10.00	20.56	30.67	40.60	50.87	61.17	71.55	82.13	91.39
6	1	12.07	21.54	31.02	41.15	50.73	60.54	70.71	80.19	90.52
6	2	9.54	19.98	29.90	39.22	49.02	59.03	69.45	79.98	90.44
6	3	10.86	21.20	30.98	41.13	50.99	61.67	71.35	81.32	91.16
6	4	10.70	20.77	31.13	41.20	50.89	61.07	70.40	80.97	91.06
6	5	11.54	21.96	31.39	42.36	52.61	61.85	72.16	81.92	90.89
6	6	10.67	21.01	31.26	41.32	51.05	60.38	71.07	80.23	90.67
6	7	12.35	22.31	32.01	41.10	50.78	61.25	71.47	80.93	91.13
6	8	11.29	20.78	30.47	40.11	50.28	60.22	70.12	80.97	91.22
6	9	11.24	20.74	30.10	40.23	50.79	60.59	70.78	80.69	90.96
6	10	10.35	20.36	30.69	40.85	50.61	61.03	70.73	80.79	90.70
7	1	9.89	19.85	29.55	38.80	48.22	58.26	68.56	79.11	90.07
7	2	10.62	19.99	30.36	40.99	50.66	60.92	71.76	81.58	90.99
7	3	11.16	21.26	31.24	41.60	52.13	61.63	71.15	81.09	90.98
7	4	12.06	22.67	32.79	42.89	52.63	62.92	72.18	82.05	91.24
7	5	12.03	22.22	31.52	41.44	51.89	61.54	71.32	80.85	90.90
7	6	12.11	21.54	32.06	41.54	51.38	61.26	71.10	80.60	91.31
7	7	11.63	21.80	31.52	41.15	51.42	61.08	71.63	81.36	91.14
7	8	10.29	19.21	29.47	39.13	48.95	59.62	69.37	79.64	90.14
7	9	9.71	19.24	29.35	38.92	48.17	58.07	68.44	79.30	90.08
7	10	11.39	21.97	31.70	42.10	52.53	62.58	72.70	82.58	91.53
8	1	11.57	21.17	30.91	40.56	50.56	60.70	70.57	80.83	90.97
8	2	10.64	20.79	30.95	41.67	51.76	61.31	70.91	81.27	91.28
8	3	11.35	21.61	31.65	41.84	51.67	61.21	70.72	81.12	90.76
8	4	12.36	23.10	32.53	42.24	52.19	62.84	72.62	81.36	91.00
8	5	11.99	21.86	32.41	42.12	51.84	61.63	71.44	81.25	90.75
8	6	11.03	21.15	31.12	40.94	50.63	59.75	70.03	80.04	90.74
8	7	11.67	21.79	31.68	40.73	50.32	60.39	70.61	80.11	90.68
8	8	11.36	20.85	30.41	40.31	50.35	60.76	71.11	81.42	91.63
8	9	10.41	19.56	29.90	40.35	51.47	60.67	70.48	80.50	90.70
8	10	11.05	21.56	31.38	41.35	50.96	61.43	70.96	80.88	91.24
9	1	11.32	21.35	31.73	42.12	52.13	62.32	72.55	81.94	91.58
9	2	11.15	21.64	31.20	40.63	51.07	61.10	70.91	80.95	90.86
9	3	12.40	22.46	31.86	41.60	51.68	60.90	70.33	80.74	90.97
9	4	11.37	22.06	31.97	42.23	52.00	61.83	72.28	81.96	91.69
9	5	10.72	21.05	31.06	40.96	50.99	61.97	71.36	80.94	91.15
9	6	11.06	20.81	30.29	40.30	50.37	60.71	70.53	81.49	91.32
9	7	11.50	20.74	31.11	41.72	52.09	61.77	72.32	81.38	90.82
9	8	11.59	21.32	31.87	41.92	52.15	61.49	71.47	81.12	90.96
9	9	12.12	21.70	32.66	41.97	50.96	60.54	70.49	80.27	90.63
9	10	11.25	22.27	31.36	41.36	51.84	61.94	71.84	82.08	91.47

Table 2: Decile by grade examination of goodness-of-fit for 2007 CSAP reading student growth percentiles using B-spline smoothing

2006	2006	Observed Percentages of SGP at or below Given Percentile								
Grade	SS Decile	10th	20th	30th	40th	50th	60th	70th	80th	90th
3	1	11.11	21.95	32.34	41.91	51.70	61.23	71.07	81.29	91.00
3	2	12.09	22.14	32.32	43.28	53.52	63.94	73.21	81.60	91.10
3	3	12.11	22.74	32.87	43.10	53.53	63.24	73.49	82.84	92.17
3	4	10.80	20.53	30.12	39.95	49.73	60.05	70.95	81.61	91.19
3	5	10.54	19.44	29.17	38.29	48.06	58.65	68.51	79.71	90.89
3	6	9.94	19.57	29.33	38.95	49.11	59.05	69.50	79.75	90.53
3	7	9.96	19.33	28.80	39.99	50.27	59.54	69.54	80.04	90.39
3	8	9.79	19.18	29.64	39.32	49.35	59.63	69.08	79.64	90.43
3	9	11.28	22.40	32.42	42.45	51.79	61.96	72.04	81.58	91.15
3	10	12.40	22.75	32.89	42.66	52.74	62.70	72.51	81.87	91.20
4	1	9.76	19.06	28.56	37.67	47.85	58.07	68.73	79.18	90.16
4	2	10.86	21.44	30.82	41.04	51.00	60.62	70.44	80.50	89.89
4	3	11.50	21.92	32.62	42.93	52.22	61.89	71.93	81.78	91.28
4	4	11.49	21.40	31.30	41.35	51.21	60.89	70.35	80.38	90.94
4	5	12.60	21.82	31.28	41.65	51.99	61.85	71.71	81.78	91.63
4	6	10.98	20.68	30.95	41.02	51.31	62.03	72.29	81.97	91.73
4	7	9.58	19.40	29.17	39.26	49.46	60.16	70.89	81.13	91.01
4	8	10.59	20.56	30.24	40.02	50.23	59.98	70.22	80.05	90.30
4	9	9.89	20.07	30.31	40.57	50.41	59.83	70.36	80.08	91.05
4	10	11.76	21.76	31.81	41.42	51.18	61.22	70.63	80.96	90.49
5	1	10.29	19.51	29.33	39.01	48.55	58.33	68.56	78.84	89.61
5	2	11.23	21.59	31.00	40.12	49.86	59.84	69.75	80.23	90.62
5	3	11.67	20.73	30.98	41.37	50.99	61.11	70.60	80.54	91.01
5	4	10.75	20.80	31.03	39.76	50.41	60.56	71.09	81.79	91.45
5	5	10.84	21.56	30.95	41.64	51.80	61.76	72.00	81.41	91.06
5	6	10.59	20.69	31.21	41.22	51.57	61.68	71.47	81.33	91.39
5	7	10.36	20.10	30.42	40.42	50.10	59.94	70.14	80.44	89.70
5	8	9.99	19.87	29.42	39.04	48.85	58.86	69.10	79.57	90.53
5	9	10.70	21.16	31.14	41.12	50.72	60.42	69.98	80.08	90.55
5	10	11.94	21.20	31.03	41.27	51.22	61.33	71.35	81.52	91.33
6	1	11.08	21.08	31.43	40.81	50.81	60.83	70.30	80.06	90.77
6	2	11.63	20.92	31.01	41.20	50.63	60.63	70.81	80.96	90.73
6	3	11.18	21.14	30.76	41.45	51.07	60.52	70.76	81.09	90.99
6	4	10.77	20.36	30.30	40.20	50.18	60.44	71.24	80.70	91.21
6	5	10.64	21.14	30.95	40.93	51.26	60.80	70.73	81.03	90.61
6	6	10.87	20.38	30.92	40.51	50.90	61.60	71.65	81.41	90.93
6	7	10.06	20.34	30.51	40.94	50.62	61.33	70.84	80.60	90.45
6	8	11.28	21.69	31.29	40.60	50.14	59.51	69.54	79.73	90.93
6	9	11.49	21.61	31.21	40.90	50.50	60.62	70.90	80.81	90.66
6	10	11.09	20.53	30.67	41.00	51.06	61.03	71.13	81.57	91.35
7	1	10.78	20.35	29.97	39.66	49.66	59.97	70.08	79.94	90.03
7	2	11.54	21.78	31.95	41.40	51.38	60.83	70.91	81.12	90.85
7	3	11.23	20.97	30.44	40.16	49.88	59.88	70.56	80.03	90.23
7	4	11.14	21.21	31.12	40.73	51.55	61.89	71.94	81.25	91.01
7	5	10.47	19.95	30.54	40.74	50.69	60.44	70.12	80.49	91.47
7	6	11.60	22.29	32.15	42.50	51.99	61.45	71.21	81.68	91.23
7	7	10.27	20.97	31.48	41.29	50.56	60.91	70.89	80.96	91.10
7	8	10.73	20.39	29.82	39.97	50.23	60.24	70.12	80.78	90.70
7	9	11.21	21.59	31.70	40.95	50.75	60.82	70.38	80.70	90.86
7	10	11.74	21.42	31.46	41.46	51.90	61.92	71.82	81.14	91.04
8	1	10.88	20.69	31.05	41.25	51.24	60.73	70.76	80.83	90.39
8	2	12.35	22.31	32.20	42.18	51.16	60.76	70.53	80.38	91.10
8	3	10.72	20.67	30.65	39.91	50.26	60.19	70.23	80.45	90.92
8	4	11.90	21.14	30.76	40.74	49.92	59.98	70.71	81.19	91.05
8	5	10.75	20.14	29.75	39.36	49.98	60.68	71.12	80.76	91.26
8	6	9.98	20.91	31.14	41.12	50.81	61.41	70.77	81.18	90.83
8	7	10.96	20.94	31.71	41.92	52.12	61.36	70.51	79.97	90.01
8	8	12.68	22.11	31.83	42.06	51.95	61.65	71.72	81.23	91.03
8	9	10.65	21.18	31.22	41.13	51.31	61.70	71.59	81.86	92.04
8	10	10.94	20.74	30.64	40.80	50.69	60.74	70.71	80.95	90.83
9	1	11.22	20.95	31.14	40.89	50.57	60.91	70.53	80.38	90.84
9	2	11.84	21.38	29.97	39.54	49.95	60.07	70.74	80.87	91.13
9	3	12.01	21.92	30.96	41.11	50.83	60.80	70.71	80.86	90.85
9	4	11.19	20.20	30.98	41.25	51.32	61.35	71.09	81.53	90.54
9	5	10.36	21.10	31.80	41.51	52.05	61.86	71.55	81.02	91.26
9	6	11.18	21.67	31.27	41.88	52.13	61.50	70.88	80.69	90.98
9	7	10.98	21.65	32.41	41.83	51.53	61.51	71.71	81.97	91.73
9	8	11.14	21.60	32.20	42.10	51.55	60.74	70.58	79.97	90.65
9	9	11.80	21.86	31.04	41.28	51.03	61.01	70.95	80.64	90.66
9	10	10.84	20.19	29.83	40.14	50.77	61.10	71.06	81.37	90.83

Table 3: Decile by grade examination of goodness-of-fit for 2007 CSAP write student growth percentiles using B-spline smoothing

2006	2006	Observed Percentages of SGP at or below Given Percentile								
Grade	SS Decile	10th	20th	30th	40th	50th	60th	70th	80th	90th
3	1	21.82	35.39	46.19	55.50	63.19	71.04	78.24	85.07	91.57
3	2	13.32	25.04	35.42	46.02	56.55	65.82	75.10	83.94	92.55
3	3	9.71	19.42	30.01	39.93	50.07	60.86	71.33	81.34	91.94
3	4	8.03	17.29	27.26	38.19	48.60	58.70	69.46	81.12	91.88
3	5	7.16	15.35	24.62	34.16	45.08	55.70	66.63	78.49	90.83
3	6	6.00	13.63	22.76	32.27	43.64	55.67	66.64	78.29	90.16
3	7	6.16	14.16	23.00	32.67	42.65	53.70	66.16	77.76	89.39
3	8	6.58	14.40	23.33	33.32	43.15	53.93	65.19	76.82	88.55
3	9	7.23	16.89	27.73	38.78	49.70	60.17	69.93	79.56	89.71
3	10	23.94	38.46	49.67	59.22	67.36	74.84	81.27	87.52	93.39
4	1	17.70	29.21	39.57	48.51	56.71	64.61	72.14	79.75	88.41
4	2	13.09	23.96	34.68	45.08	54.88	63.81	72.94	82.44	91.55
4	3	11.33	21.04	30.44	40.48	50.75	61.37	72.12	82.54	92.12
4	4	9.45	19.66	29.28	40.43	50.16	60.36	71.63	81.69	92.70
4	5	8.46	17.71	27.48	37.59	48.22	58.89	69.82	80.45	91.88
4	6	7.40	15.84	25.31	34.95	46.12	57.95	68.87	80.56	90.96
4	7	7.36	16.33	26.26	35.97	46.50	57.22	68.16	79.74	90.75
4	8	7.62	16.44	26.28	36.30	46.99	57.66	67.90	78.40	90.02
4	9	8.86	19.03	28.77	38.94	48.90	58.71	69.66	79.55	89.65
4	10	19.18	31.53	42.53	52.16	60.38	68.34	75.77	83.16	90.41
5	1	18.36	28.63	37.40	45.11	52.95	60.43	68.14	76.41	86.71
5	2	13.06	23.07	32.86	43.03	52.74	62.51	73.14	82.68	91.80
5	3	10.15	20.62	30.58	41.10	51.89	62.54	72.89	83.66	92.91
5	4	9.04	19.65	31.20	42.06	53.05	63.72	74.06	84.23	93.61
5	5	9.62	19.93	31.09	41.44	52.35	63.01	73.92	83.80	92.72
5	6	8.70	18.60	28.68	39.58	50.16	60.42	71.00	81.93	92.04
5	7	8.59	18.10	27.99	38.76	48.54	59.92	70.11	80.69	91.00
5	8	7.72	15.95	25.63	35.07	45.79	55.75	66.69	77.60	89.65
5	9	8.26	17.26	26.40	35.55	45.40	55.92	66.14	76.94	88.56
5	10	17.74	29.81	39.47	48.94	57.37	65.47	73.42	81.18	89.56
6	1	15.71	24.83	31.94	39.61	47.66	55.47	64.14	73.35	84.61
6	2	11.86	21.74	32.55	42.37	51.67	61.20	71.74	81.83	91.53
6	3	11.00	21.44	31.83	43.05	54.45	65.21	75.47	85.21	93.92
6	4	9.90	20.24	31.72	43.27	54.16	64.68	74.73	84.80	93.82
6	5	10.05	20.33	31.29	42.54	53.30	64.37	74.87	84.86	93.96
6	6	9.54	20.95	31.67	42.40	52.83	63.19	73.74	84.46	93.79
6	7	8.30	18.21	29.30	39.51	49.98	61.47	72.03	82.19	92.36
6	8	8.78	18.40	28.22	37.91	48.26	58.35	68.89	79.03	90.43
6	9	8.33	16.73	25.66	34.59	44.12	54.07	64.75	75.77	87.27
6	10	17.08	27.29	35.62	44.19	52.39	60.35	68.51	77.01	86.55
7	1	15.22	25.04	33.18	40.99	48.85	56.98	65.25	74.92	85.73
7	2	13.47	23.39	33.92	43.81	54.14	63.41	73.74	82.60	91.94
7	3	10.97	21.18	31.88	42.35	52.44	62.67	73.12	83.58	93.64
7	4	10.44	20.48	31.09	42.34	53.05	64.17	73.72	83.72	93.51
7	5	9.48	19.65	30.06	40.57	51.58	63.01	73.82	83.55	92.58
7	6	8.44	17.89	28.83	39.90	51.22	61.87	72.45	82.19	91.98
7	7	8.11	18.11	27.76	38.39	49.38	60.04	70.72	81.19	91.38
7	8	8.08	17.70	27.74	37.78	47.45	57.43	67.93	79.52	89.56
7	9	8.57	18.68	27.62	36.70	45.71	55.03	65.33	75.61	87.97
7	10	18.08	27.82	36.79	45.46	53.79	62.19	70.67	79.26	88.72
8	1	14.54	23.74	32.25	40.98	48.67	56.77	64.73	74.11	85.22
8	2	13.76	24.22	34.37	43.92	54.18	63.90	73.71	82.78	91.96
8	3	12.65	22.80	32.95	43.77	54.21	64.61	74.42	84.11	93.49
8	4	12.02	22.91	33.83	44.13	54.50	64.88	74.91	84.28	93.04
8	5	10.14	20.51	30.99	41.72	52.68	63.03	74.10	84.79	93.90
8	6	8.55	18.60	28.38	38.67	50.27	61.80	72.40	83.21	93.13
8	7	7.54	17.32	27.88	38.13	48.95	60.21	70.99	81.92	92.36
8	8	7.57	17.12	26.99	37.46	47.51	58.02	69.03	79.55	90.86
8	9	8.68	18.11	27.92	38.37	48.35	58.11	67.86	78.10	89.13
8	10	17.13	27.05	36.10	44.02	51.88	59.69	67.59	75.86	85.14
9	1	11.83	20.63	29.21	36.90	44.85	53.94	63.46	72.89	84.44
9	2	14.10	24.16	33.68	44.02	53.82	63.33	73.84	81.90	92.40
9	3	13.46	24.72	35.25	46.10	56.20	66.43	75.98	84.07	93.48
9	4	11.90	22.41	33.31	43.44	54.24	64.09	73.07	82.35	93.00
9	5	10.09	20.61	30.92	40.99	51.12	61.11	72.12	82.41	92.48
9	6	9.38	19.46	29.71	40.33	50.15	60.45	71.29	80.92	92.02
9	7	8.87	17.86	27.72	37.82	47.89	58.77	69.32	79.50	91.31
9	8	7.72	16.54	26.23	36.96	48.02	58.10	68.72	78.71	90.59
9	9	8.63	18.79	28.71	37.83	47.85	57.77	68.57	77.62	89.02
9	10	14.30	23.80	32.70	41.32	50.06	58.62	67.16	75.15	86.17

Table 4: Decile by grade examination of goodness-of-fit for 2007 CSAP math student growth percentiles using linear conditional percentiles

2006 Grade	2006 SS Decile	Observed Percentages of SGP at or below Given Percentile								
		10th	20th	30th	40th	50th	60th	70th	80th	90th
3	1	19.55	29.91	38.73	47.17	55.97	63.37	71.58	80.37	89.59
3	2	13.94	25.44	37.38	48.06	57.89	68.26	77.77	87.03	95.42
3	3	10.21	20.93	32.31	43.09	53.94	64.76	75.55	85.74	94.97
3	4	8.98	19.88	30.06	40.38	50.87	62.37	73.48	83.98	93.71
3	5	6.78	15.46	26.32	38.21	49.33	61.09	72.26	82.68	92.70
3	6	6.94	15.71	24.89	34.88	45.98	56.76	67.84	79.15	90.76
3	7	6.19	14.18	23.82	33.91	44.44	54.78	65.83	77.39	89.40
3	8	5.89	15.01	23.65	33.59	44.03	53.92	63.98	75.43	87.78
3	9	8.03	17.96	27.64	37.57	46.75	56.89	66.84	76.25	86.73
3	10	23.60	35.15	45.38	53.41	61.25	68.08	75.09	82.26	89.13
4	1	15.95	25.63	34.31	42.05	50.18	58.24	66.36	75.37	86.02
4	2	12.99	23.80	34.94	45.34	55.45	65.84	76.15	85.84	94.86
4	3	11.89	22.76	32.92	44.18	54.98	65.59	76.85	87.12	95.41
4	4	9.04	18.98	30.55	42.05	53.68	64.35	74.99	85.33	94.68
4	5	8.87	18.89	29.22	40.16	51.22	62.02	72.74	83.51	93.83
4	6	7.86	17.40	27.12	37.76	48.38	59.89	69.95	81.01	91.83
4	7	8.24	17.52	27.15	36.82	47.10	57.50	67.68	78.84	90.10
4	8	7.77	17.02	27.04	36.41	46.58	56.56	67.02	77.80	89.00
4	9	9.55	19.04	28.20	37.71	46.83	56.48	66.43	76.12	87.22
4	10	18.49	29.53	38.37	46.72	54.44	62.08	69.61	77.26	85.87
5	1	18.54	29.25	38.13	47.10	55.13	62.74	69.82	77.89	87.05
5	2	11.11	21.82	32.29	42.40	52.68	62.28	73.12	83.53	93.44
5	3	9.09	19.37	30.45	41.27	51.62	62.29	73.09	83.98	93.29
5	4	8.49	19.14	30.11	40.45	51.49	62.22	73.60	84.22	93.79
5	5	7.67	16.03	26.02	36.96	48.03	59.76	70.86	81.38	92.37
5	6	7.60	17.39	26.68	37.45	48.79	59.78	70.55	81.05	91.94
5	7	8.32	16.92	27.00	37.11	47.42	58.48	69.03	80.12	90.56
5	8	9.01	18.00	27.68	37.61	47.76	57.61	67.64	77.25	88.73
5	9	11.24	20.65	30.29	39.51	48.35	57.35	66.43	76.42	86.98
5	10	18.90	30.65	40.22	48.96	57.44	65.13	73.02	81.14	89.41
6	1	17.91	27.50	36.35	44.09	52.44	60.15	68.45	76.70	86.72
6	2	11.87	22.55	32.52	42.34	52.61	62.79	73.32	83.22	92.61
6	3	10.37	21.11	31.35	42.09	52.32	63.24	73.88	83.99	93.83
6	4	9.22	18.93	29.43	40.34	50.87	61.70	71.58	82.79	93.19
6	5	8.89	18.93	28.59	39.58	50.82	61.36	72.22	82.82	92.44
6	6	7.37	16.93	27.23	38.21	48.74	59.03	70.11	80.27	91.55
6	7	8.85	18.11	28.44	37.92	48.09	58.81	69.90	80.14	91.04
6	8	8.17	17.85	27.31	37.45	47.46	57.69	67.99	79.22	90.08
6	9	10.05	19.90	29.50	39.33	49.09	58.54	68.26	78.51	88.94
6	10	18.91	29.57	39.10	47.25	55.62	63.75	71.53	79.41	87.54
7	1	12.49	21.21	29.12	36.94	44.64	53.17	62.16	72.52	84.29
7	2	11.64	22.48	33.67	44.53	54.81	65.21	75.47	85.21	93.69
7	3	11.34	22.11	33.25	44.15	55.14	65.54	75.30	85.14	94.01
7	4	11.37	22.53	33.37	44.43	54.92	65.36	75.39	84.47	94.07
7	5	10.98	21.16	31.10	41.42	52.57	62.77	73.35	82.96	92.92
7	6	10.45	19.89	30.24	40.42	50.70	61.15	71.40	81.91	92.30
7	7	9.86	19.47	29.04	38.99	49.57	59.98	70.71	80.92	91.16
7	8	8.80	17.00	26.83	36.40	46.17	57.08	67.21	77.91	88.87
7	9	8.73	17.80	27.30	36.70	45.42	54.65	64.84	76.10	87.32
7	10	15.44	26.05	34.94	43.82	52.71	61.57	70.30	78.71	87.94
8	1	13.17	21.21	29.16	37.28	45.95	54.87	63.77	73.95	85.44
8	2	11.59	22.23	33.47	44.55	54.87	64.71	74.45	84.73	93.97
8	3	11.35	22.28	33.42	44.50	55.10	64.97	75.05	85.45	93.84
8	4	11.67	23.41	33.80	43.97	55.06	66.35	75.91	84.72	93.57
8	5	11.02	21.57	32.85	43.23	53.51	63.75	74.12	83.66	93.12
8	6	9.78	20.61	30.71	41.05	51.04	60.53	71.52	81.79	92.03
8	7	10.26	20.62	30.64	39.89	49.72	60.13	70.53	80.22	91.11
8	8	10.56	19.67	28.89	38.62	48.64	59.13	69.48	80.06	90.78
8	9	9.88	18.56	27.91	38.10	48.32	57.74	67.54	77.41	87.88
8	10	14.04	23.07	31.65	40.39	48.68	57.40	65.78	75.20	85.83
9	1	15.66	26.28	35.06	43.45	51.40	59.05	66.70	75.12	85.25
9	2	12.92	23.51	33.47	43.64	54.11	63.65	73.86	83.40	93.07
9	3	12.11	22.24	32.49	42.96	53.35	63.56	73.17	84.56	94.03
9	4	9.93	20.42	31.07	42.21	52.72	63.66	74.80	84.77	94.05
9	5	8.87	18.77	29.02	39.84	50.64	62.54	73.09	83.40	93.17
9	6	8.50	17.70	27.79	38.49	49.06	60.36	71.14	82.30	92.59
9	7	8.85	17.93	28.15	38.91	49.96	60.64	71.66	81.19	90.94
9	8	9.08	18.92	29.20	39.49	49.90	59.82	69.90	79.78	90.16
9	9	10.74	21.47	31.73	40.73	49.51	58.42	68.23	78.07	88.31
9	10	18.61	29.31	37.79	46.08	53.96	61.98	69.54	78.07	87.38

Table 5: Decile by grade examination of goodness-of-fit for 2007 CSAP read student growth percentiles using linear conditional percentiles

2006	2006	Observed Percentages of SGP at or below Given Percentile								
Grade	SS Decile	10th	20th	30th	40th	50th	60th	70th	80th	90th
3	1	18.20	29.94	40.18	49.20	57.62	65.78	74.02	81.88	90.33
3	2	14.15	25.49	36.70	46.98	57.83	67.68	76.42	85.03	93.46
3	3	12.01	23.09	33.63	44.32	54.61	65.11	75.00	84.58	93.99
3	4	9.19	18.75	28.71	38.97	48.81	59.63	71.31	82.55	92.53
3	5	8.37	16.82	25.68	35.39	45.59	57.03	67.72	79.56	91.61
3	6	7.22	15.78	25.48	35.04	45.33	56.28	67.69	78.71	90.59
3	7	6.69	15.13	23.87	34.92	46.04	55.85	66.66	77.98	89.54
3	8	6.72	14.77	24.65	34.60	45.39	55.50	65.94	77.30	88.83
3	9	8.21	18.86	29.05	39.70	48.88	59.03	69.19	79.58	88.96
3	10	19.00	31.22	41.79	50.61	59.62	67.81	75.76	82.78	90.15
4	1	12.74	21.62	30.20	38.57	47.58	56.12	65.83	75.32	86.69
4	2	13.49	24.48	34.78	44.95	54.19	64.00	73.51	83.13	91.90
4	3	12.53	23.94	34.68	45.43	54.98	64.99	74.89	84.59	93.38
4	4	11.39	21.44	31.82	42.20	52.51	62.56	72.38	82.45	92.60
4	5	11.43	21.04	30.65	41.16	51.99	62.21	72.68	82.83	92.65
4	6	9.16	18.75	29.10	39.41	50.17	61.31	72.10	82.36	92.24
4	7	7.57	16.71	26.63	36.65	47.55	58.26	69.47	80.37	90.82
4	8	8.33	17.67	27.24	37.00	47.21	57.88	68.34	78.59	89.45
4	9	7.75	17.29	27.30	37.54	47.78	57.42	67.50	78.01	89.24
4	10	15.12	25.72	35.35	44.66	53.14	61.67	70.57	79.52	88.80
5	1	15.11	24.89	33.40	41.43	49.13	57.17	65.45	74.63	85.21
5	2	13.08	24.23	33.37	42.82	52.12	61.84	71.49	81.75	91.61
5	3	11.70	20.75	31.63	42.43	52.23	62.65	72.14	82.17	92.46
5	4	9.88	19.65	30.34	39.42	50.72	61.13	72.41	83.38	92.62
5	5	9.18	19.50	29.21	40.19	51.14	61.82	72.66	82.22	91.86
5	6	8.25	18.11	28.55	39.28	50.12	61.01	71.27	81.70	91.94
5	7	8.21	17.34	27.68	38.01	48.26	58.91	69.51	80.20	89.87
5	8	7.78	17.39	26.98	36.78	46.89	57.13	67.62	78.93	89.89
5	9	9.56	20.15	29.83	39.81	49.41	59.03	68.64	78.54	89.41
5	10	16.46	26.46	36.08	45.19	54.09	62.64	71.44	80.76	90.27
6	1	14.17	23.53	31.66	39.51	47.00	55.26	62.91	71.89	83.23
6	2	13.28	23.00	33.31	43.15	52.40	62.75	72.47	82.13	91.72
6	3	11.52	22.01	31.97	43.01	53.11	62.83	73.43	83.69	92.96
6	4	10.24	20.11	30.51	41.07	51.81	62.54	73.38	83.41	93.30
6	5	9.53	19.89	30.09	40.87	51.83	62.20	72.96	82.94	92.01
6	6	9.31	18.92	29.40	39.57	50.80	61.95	72.30	82.78	92.20
6	7	8.46	17.99	28.78	39.53	49.49	60.88	70.98	81.24	91.41
6	8	9.11	19.40	29.34	38.69	48.63	58.25	68.96	79.16	90.74
6	9	10.16	20.32	29.51	39.26	48.70	58.24	68.68	78.97	89.45
6	10	14.77	24.35	33.73	42.92	51.36	60.39	69.07	78.66	88.55
7	1	12.39	21.14	29.63	37.59	44.72	53.14	61.78	70.29	80.84
7	2	13.01	23.59	33.79	42.95	52.68	62.18	72.00	81.73	91.71
7	3	11.92	22.09	31.75	42.00	51.92	62.59	72.80	82.88	92.86
7	4	11.09	21.27	31.46	42.02	53.71	64.33	74.71	84.12	93.68
7	5	9.85	19.39	30.29	41.13	51.68	61.86	72.35	83.64	94.04
7	6	10.17	20.92	31.17	42.01	52.55	62.48	73.12	83.57	93.15
7	7	8.87	19.16	30.04	40.05	49.94	60.98	71.39	81.94	92.26
7	8	9.07	18.52	28.10	38.12	49.19	59.20	69.33	80.31	90.78
7	9	9.98	20.14	30.02	39.42	48.71	59.03	68.66	79.06	89.30
7	10	14.54	24.17	33.61	42.53	51.38	59.91	68.58	77.07	86.68
8	1	11.51	20.08	28.30	36.09	44.41	52.34	60.89	70.53	81.42
8	2	13.24	23.69	33.66	42.99	52.23	61.93	71.27	81.76	92.05
8	3	11.37	21.63	32.04	41.89	52.86	63.00	73.32	83.42	93.58
8	4	11.80	21.76	31.83	42.82	52.48	63.18	74.17	84.72	93.42
8	5	10.25	19.97	30.60	40.96	52.19	63.35	73.99	83.81	93.58
8	6	9.34	20.35	31.04	42.06	52.41	63.01	73.12	83.35	92.62
8	7	10.21	19.90	30.85	41.48	52.50	62.16	71.52	81.09	91.36
8	8	11.29	20.82	30.52	40.72	51.28	61.23	71.53	80.94	91.32
8	9	9.74	19.92	29.60	39.26	49.17	59.63	69.52	79.89	90.47
8	10	12.88	22.32	31.15	39.56	48.36	57.11	66.38	76.51	86.61
9	1	12.47	21.59	30.61	38.23	47.09	55.29	63.71	72.43	83.69
9	2	12.90	22.62	31.93	41.41	51.37	61.35	71.65	81.53	91.27
9	3	12.42	22.88	32.11	42.74	52.32	62.47	72.87	82.84	92.32
9	4	11.25	20.63	31.10	42.17	52.71	63.06	73.15	83.75	92.58
9	5	9.89	20.55	31.57	41.81	52.67	62.97	73.00	83.07	92.91
9	6	10.15	20.46	30.49	41.38	52.05	62.00	72.17	82.22	92.67
9	7	9.92	20.08	30.92	40.96	50.74	61.41	72.07	82.83	92.75
9	8	10.12	20.03	30.57	40.39	50.02	60.02	70.27	80.05	90.85
9	9	10.77	20.55	30.13	40.04	49.36	59.72	69.36	79.45	89.77
9	10	12.84	22.63	32.10	41.31	51.30	59.98	68.75	77.86	87.30

Table 6: Decile by grade examination of goodness-of-fit for 2007 CSAP write student growth percentiles using linear conditional percentiles

Supplementary Figures: Ethnicity

The following figures present boxplots associated with 2007 student growth percentiles by subject crossed with ethnicity. Because growth percentiles are uniformly distributed between 0 and 99, random assignment of students to subgroup would yield a median growth percentile for the subgroup of approximately 50.

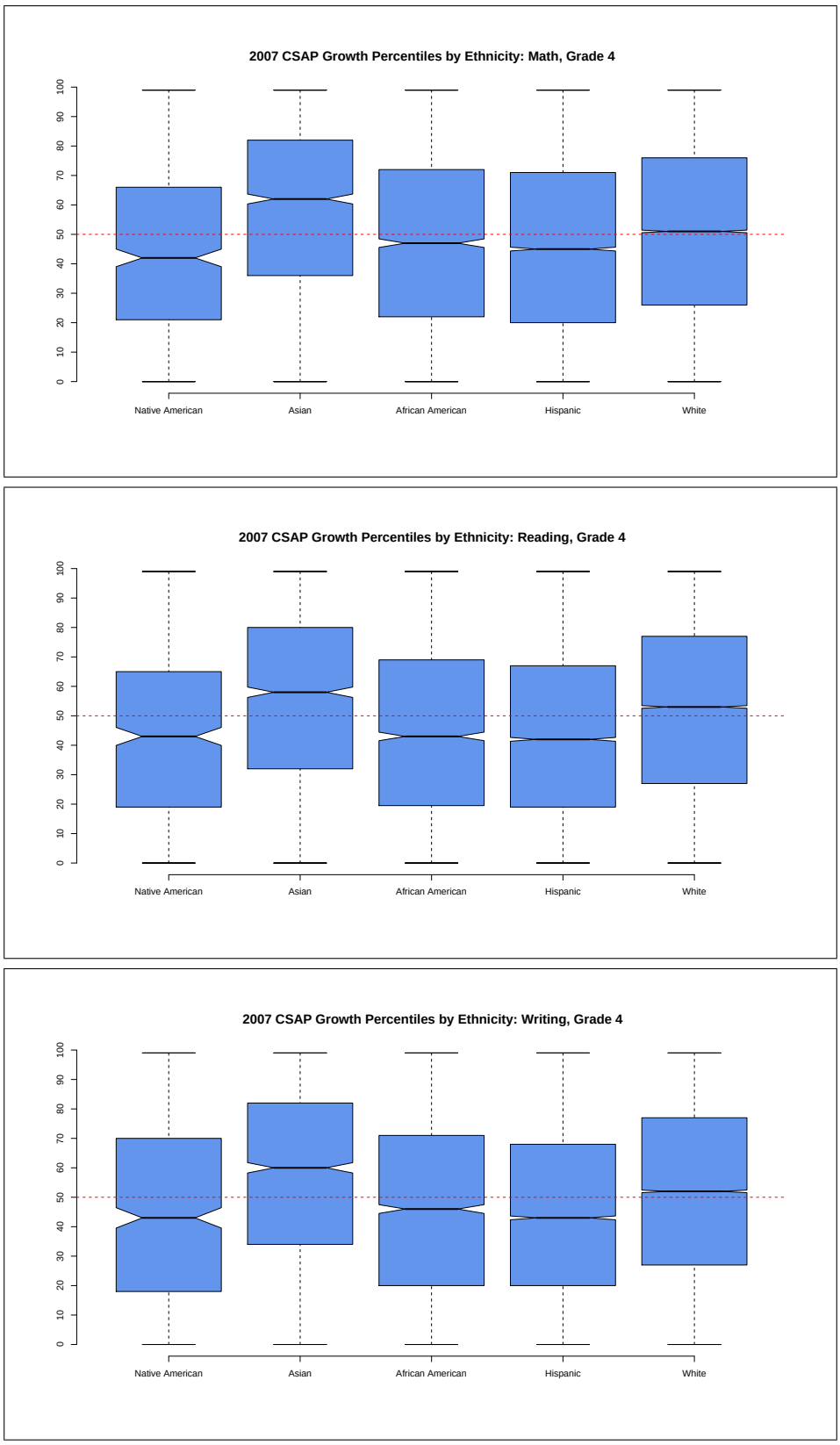

Figure 3: Boxplots of student growth percentiles by ethnicity for 2007 grade 4 math, reading, and writing

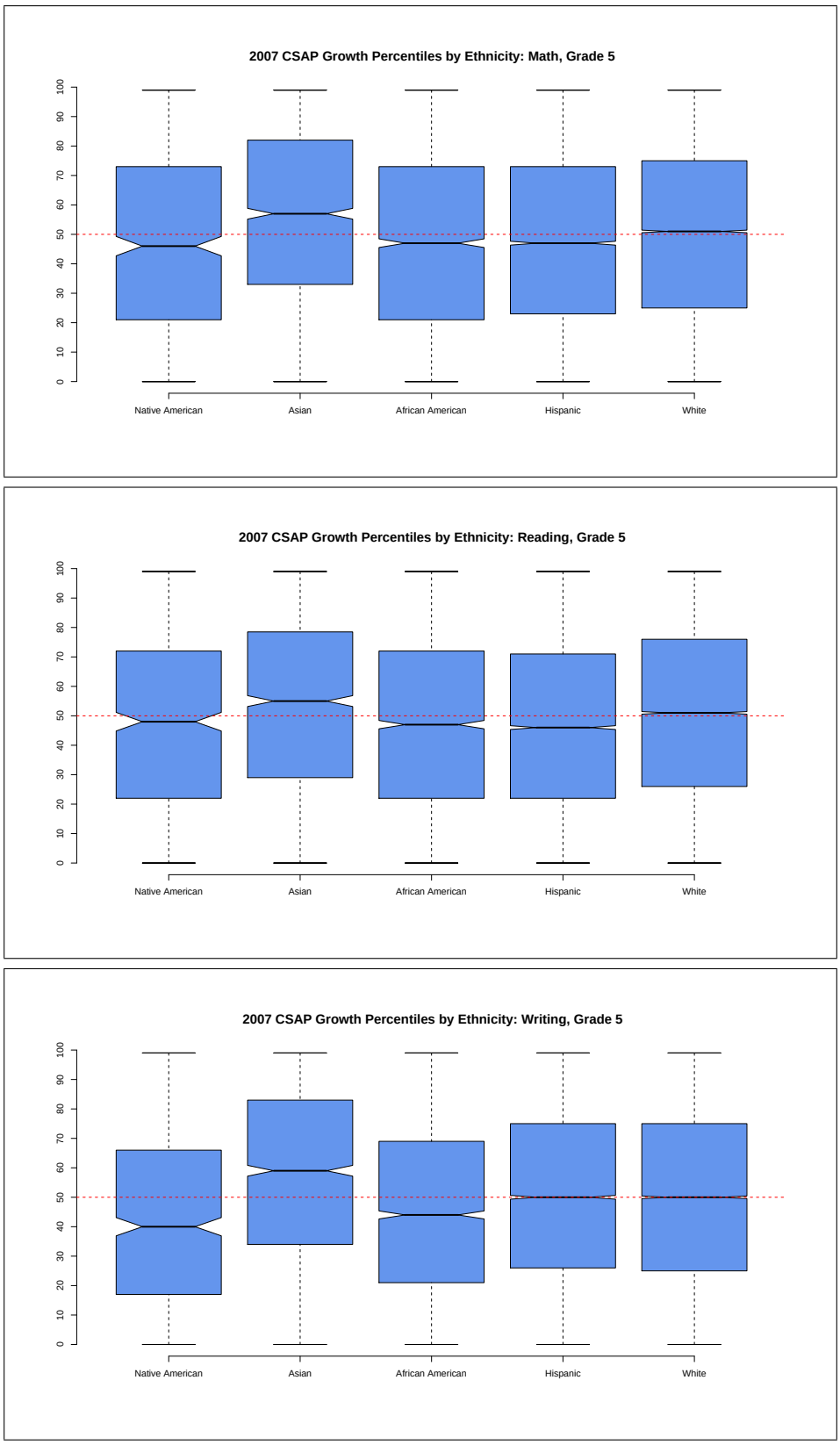

Figure 4: Boxplots of student growth percentiles by ethnicity for 2007 grade 5 math, reading, and writing

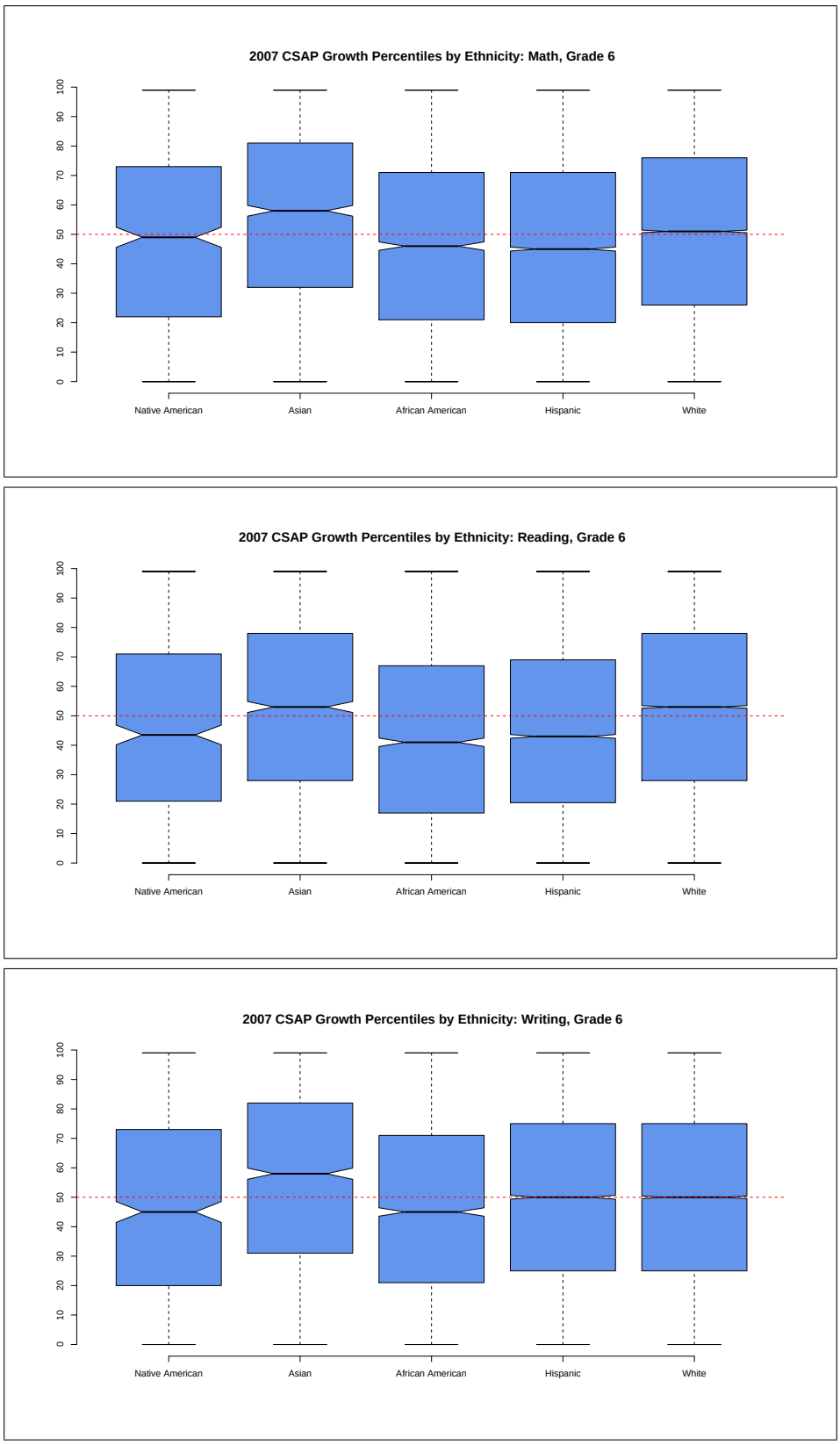

Figure 5: Boxplots of student growth percentiles by ethnicity for 2007 grade 6 math, reading, and writing

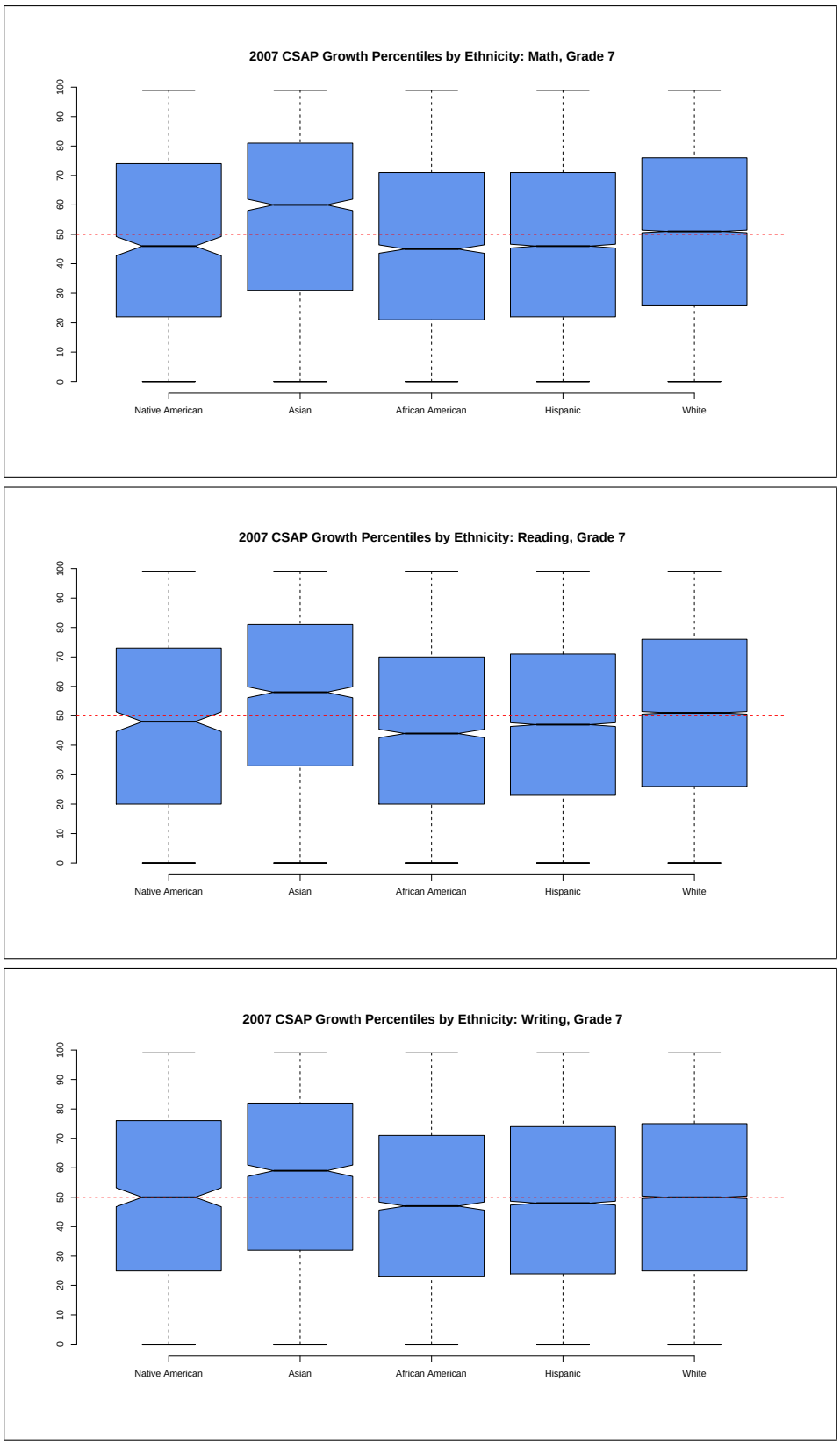

Figure 6: Boxplots of student growth percentiles by ethnicity for 2007 grade 7 math, reading, and writing

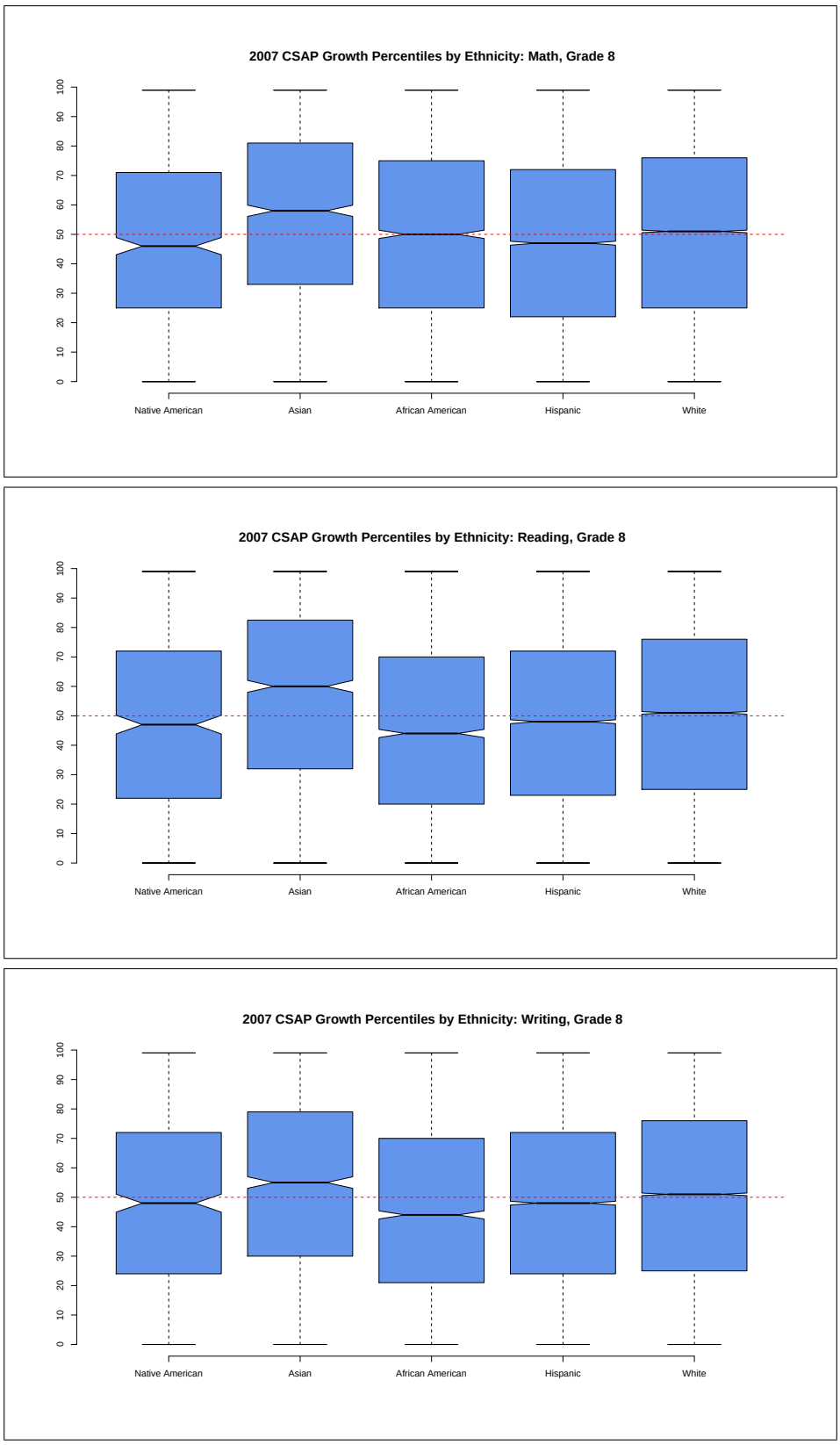

Figure 7: Boxplots of student growth percentiles by ethnicity for 2007 grade 8 math, reading, and writing

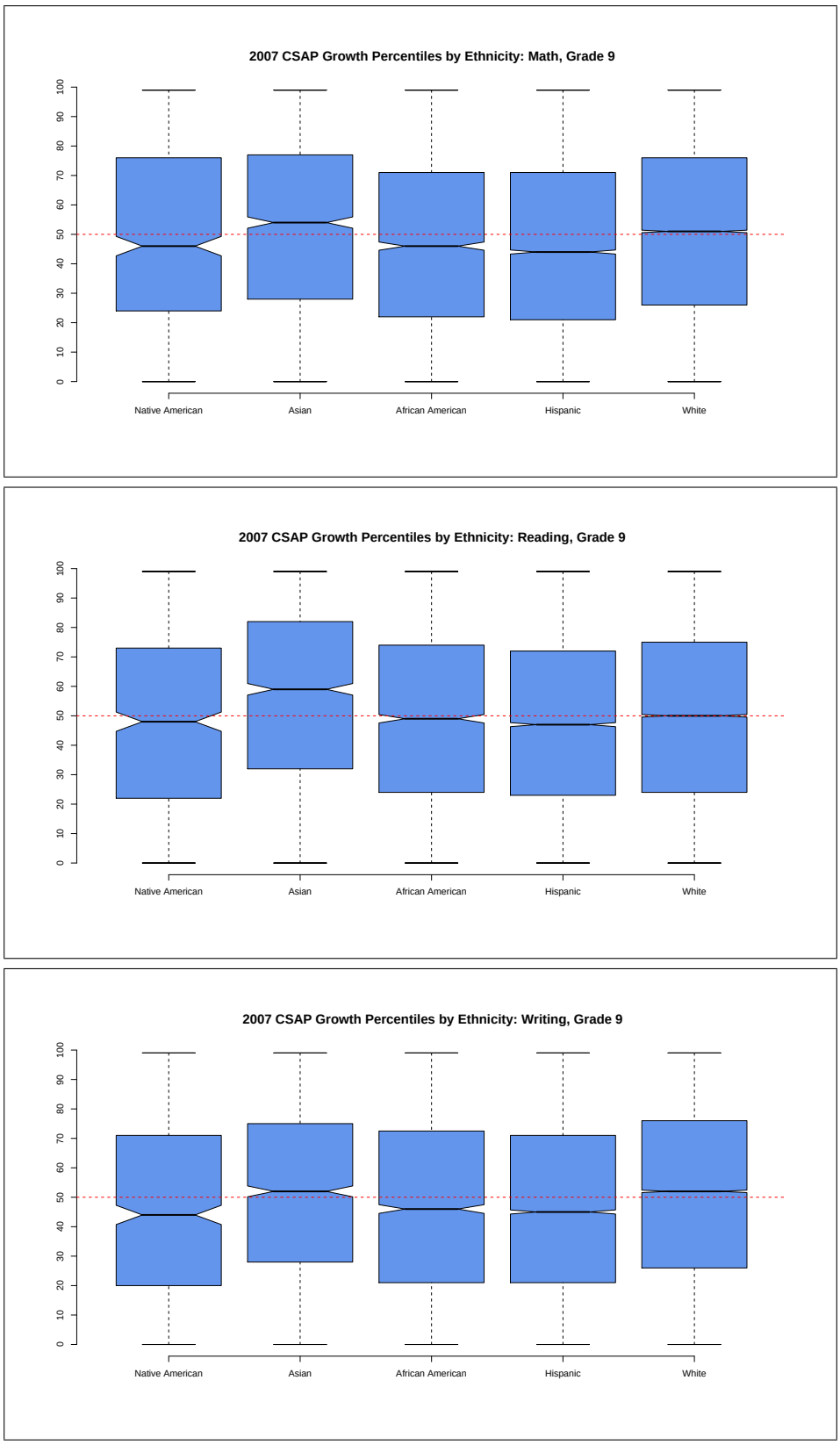

Figure 8: Boxplots of student growth percentiles by ethnicity for 2007 grade 9 math, reading, and writing

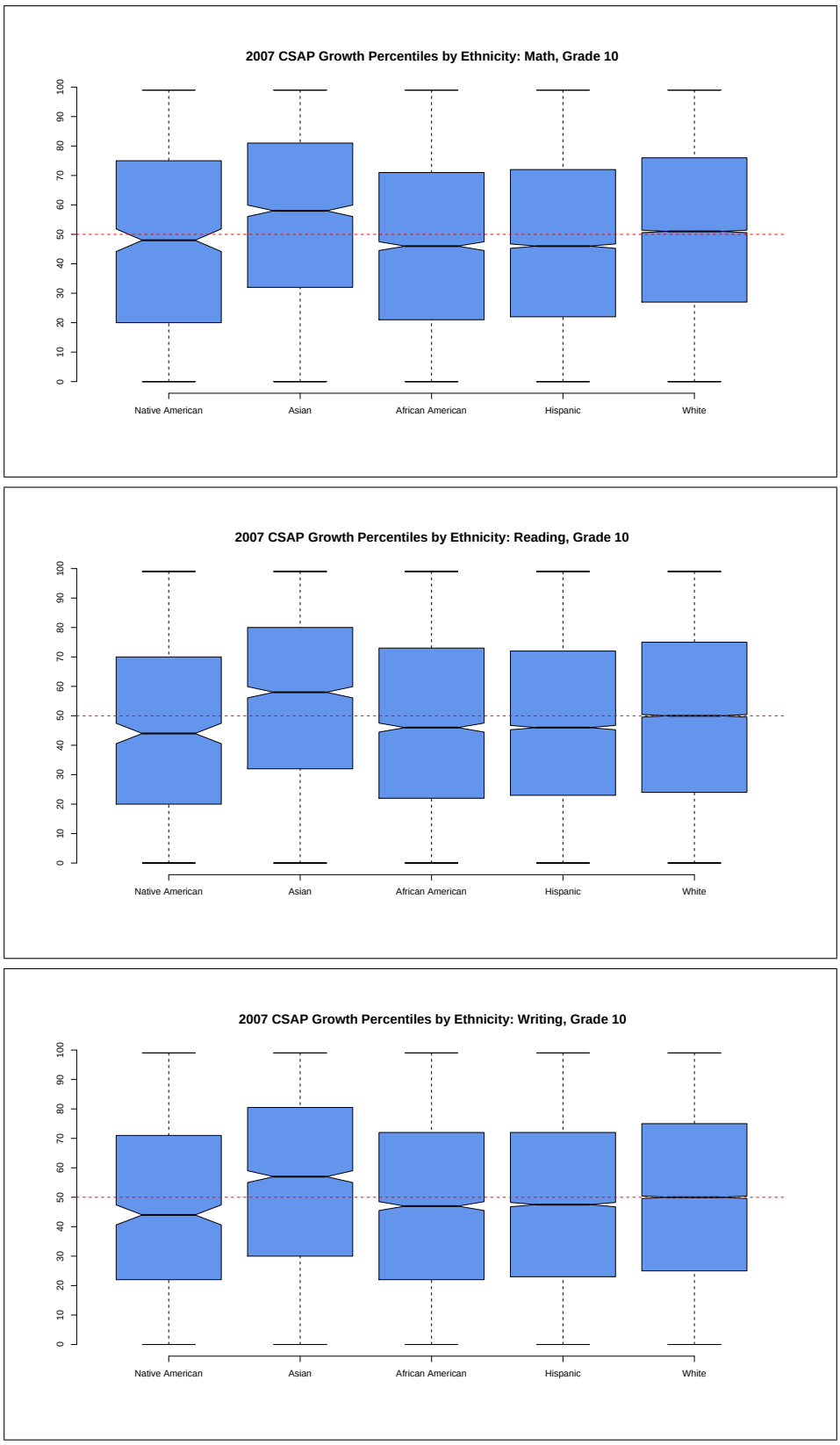

Figure 9: Boxplots of student growth percentiles by ethnicity for 2007 grade 10 math, reading, and writing

Supplementary Figures: Gender

The following figures present boxplots associated with 2007 student growth percentiles by subject crossed with gender. Because growth percentiles are uniformly distributed between 0 and 99, random assignment of students to subgroup would yield a median growth percentile for the subgroup of approximately 50.

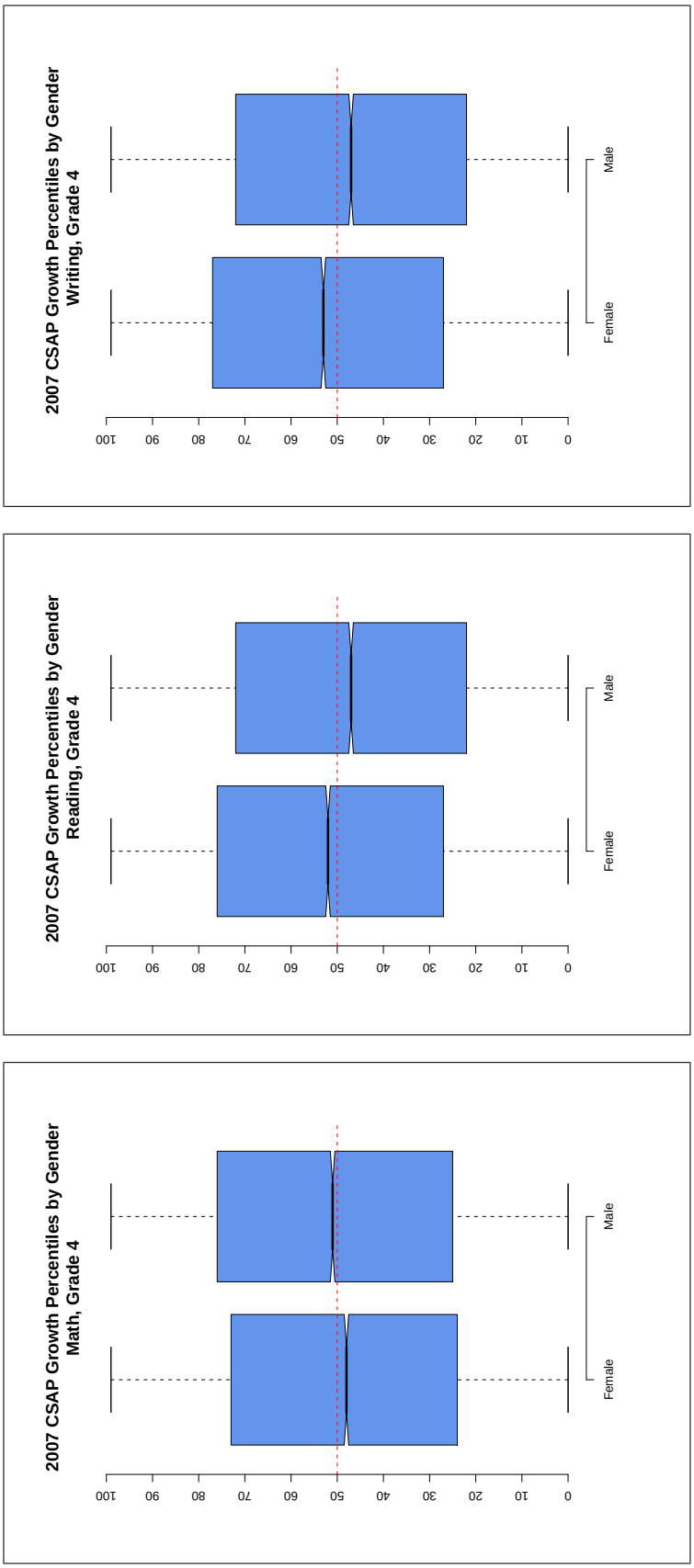

Figure 10: Boxplots of student growth percentiles by gender for 2007 grade 4 math, reading, and writing

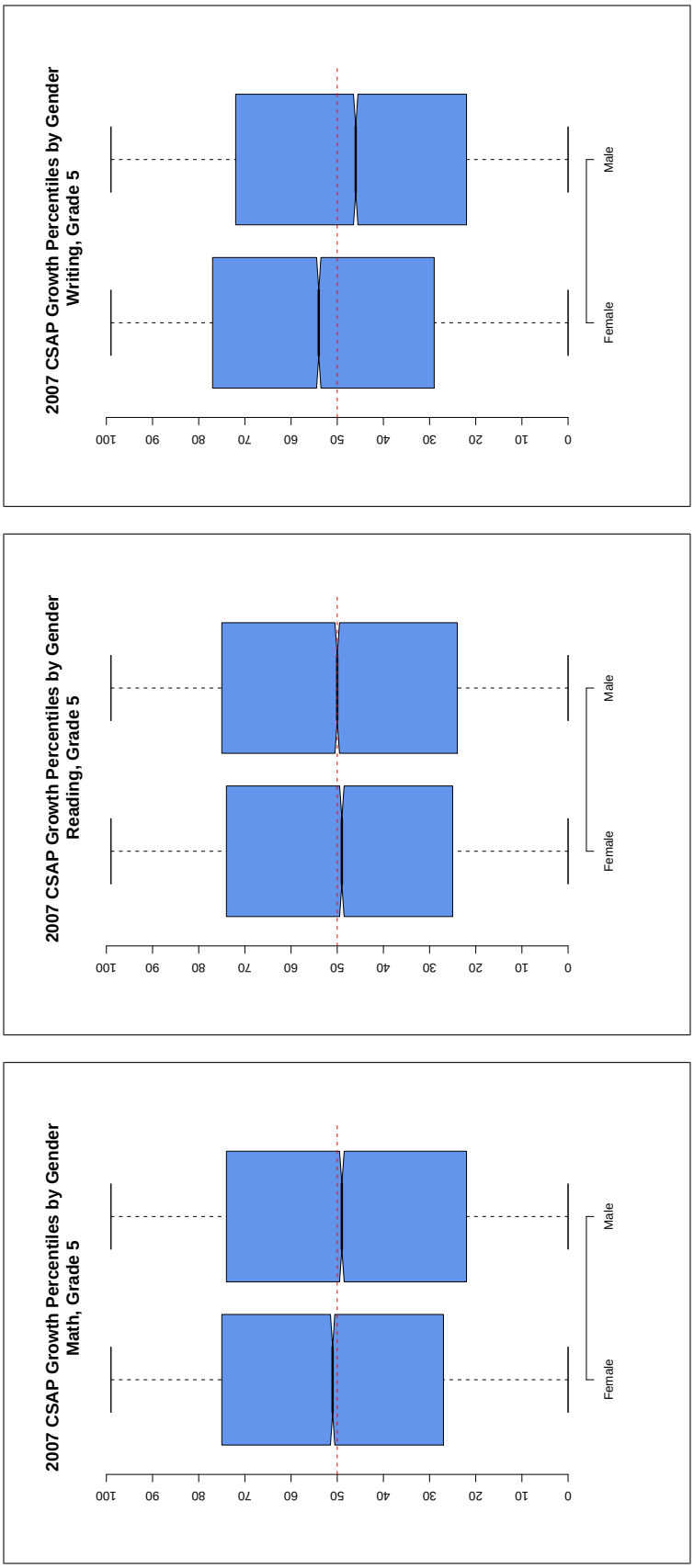

Figure 11: Boxplots of student growth percentiles by gender for 2007 grade 5 math, reading, and writing

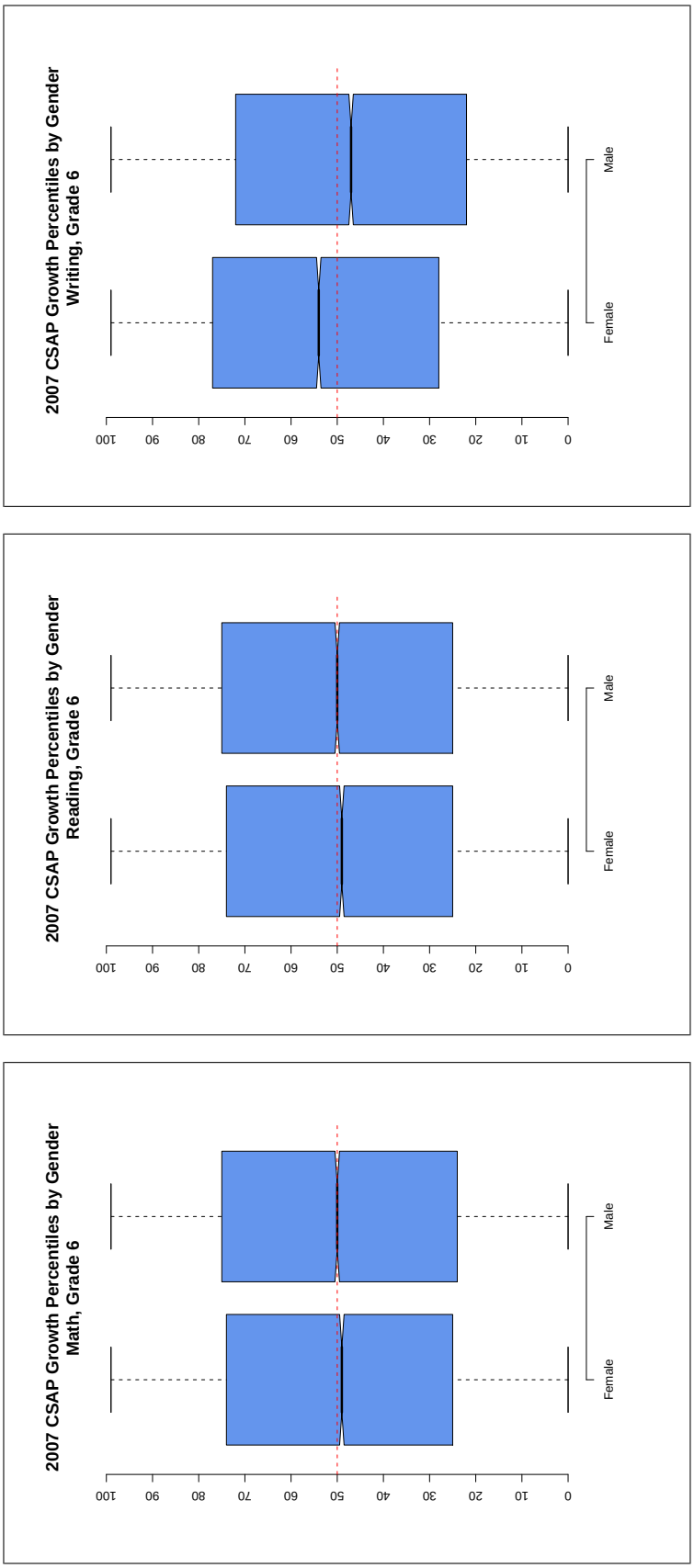

Figure 12: Boxplots of student growth percentiles by gender for 2007 grade 6 math, reading, and writing

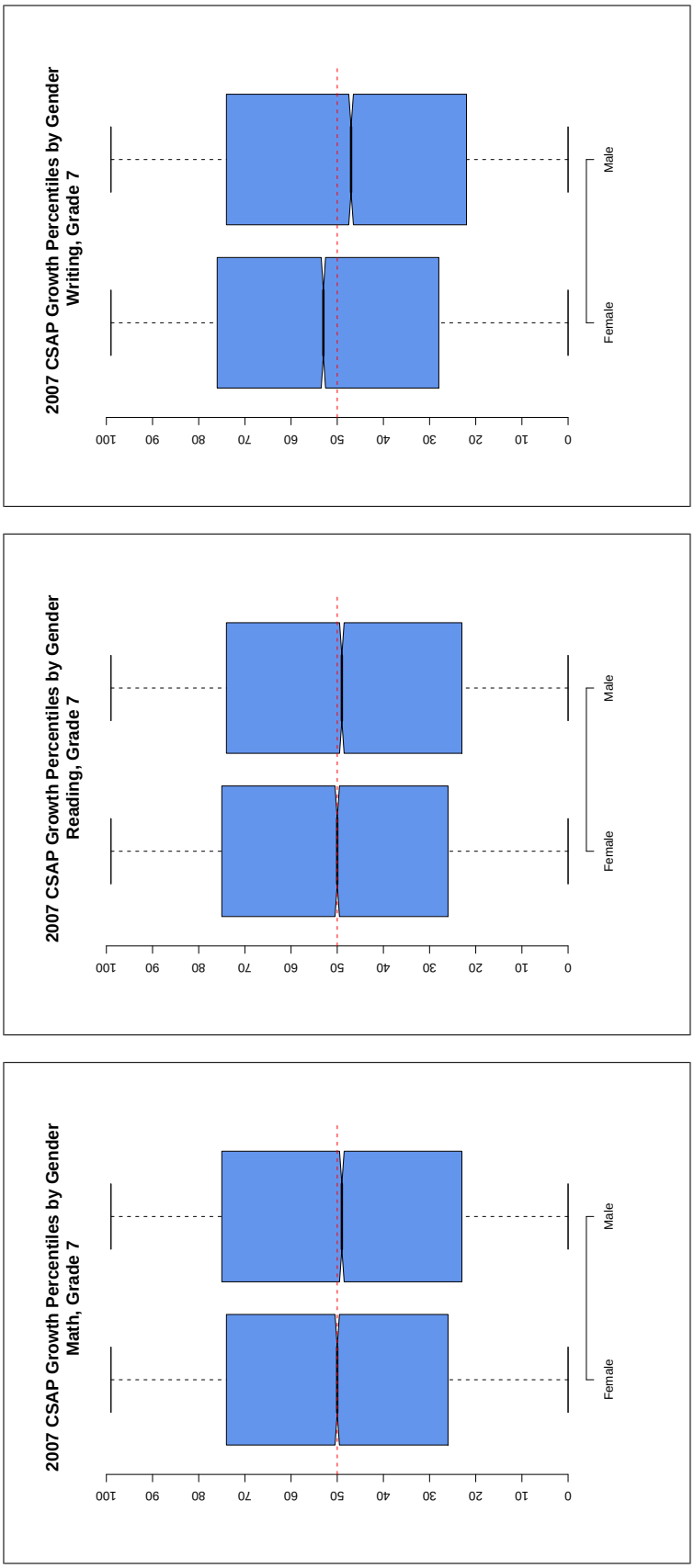

Figure 13: Boxplots of student growth percentiles by gender for 2007 grade 7 math, reading, and writing

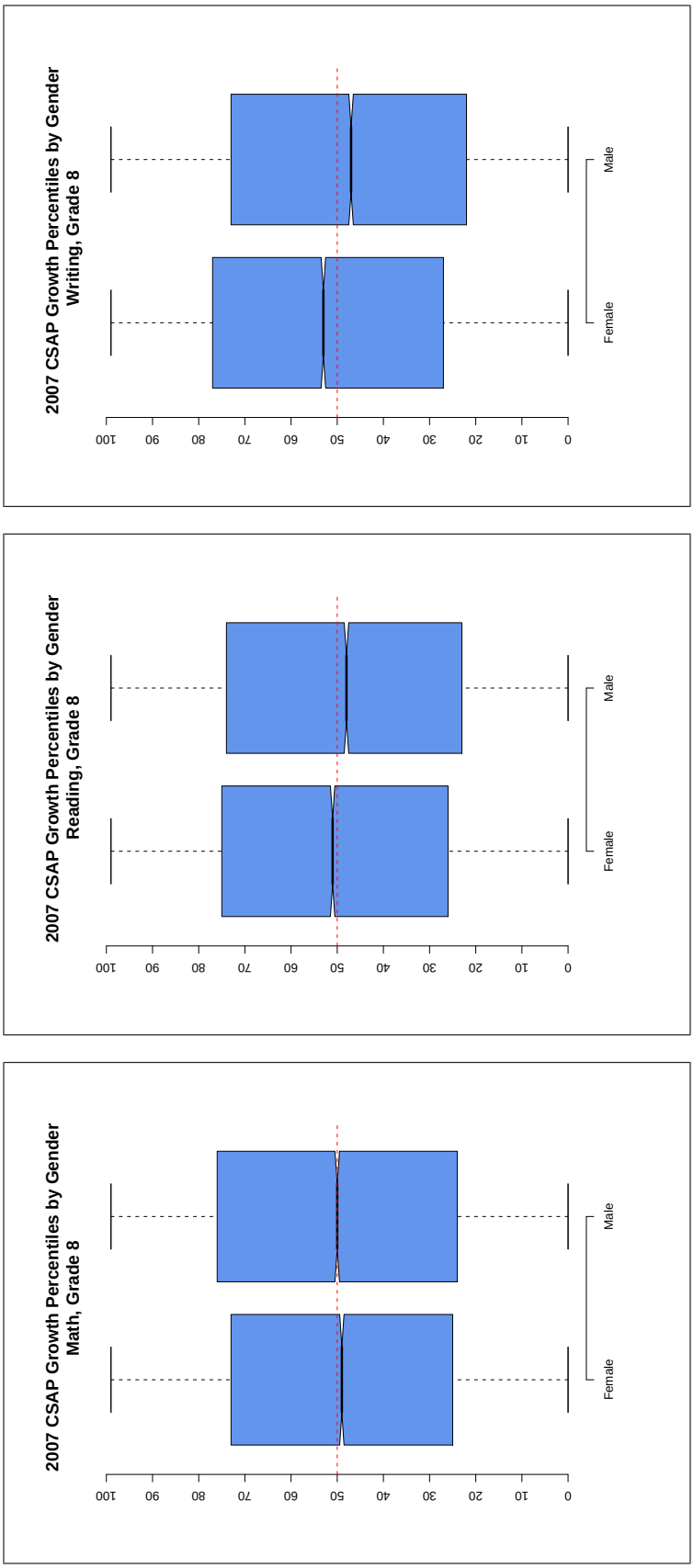

Figure 14: Boxplots of student growth percentiles by gender for 2007 grade 8 math, reading, and writing

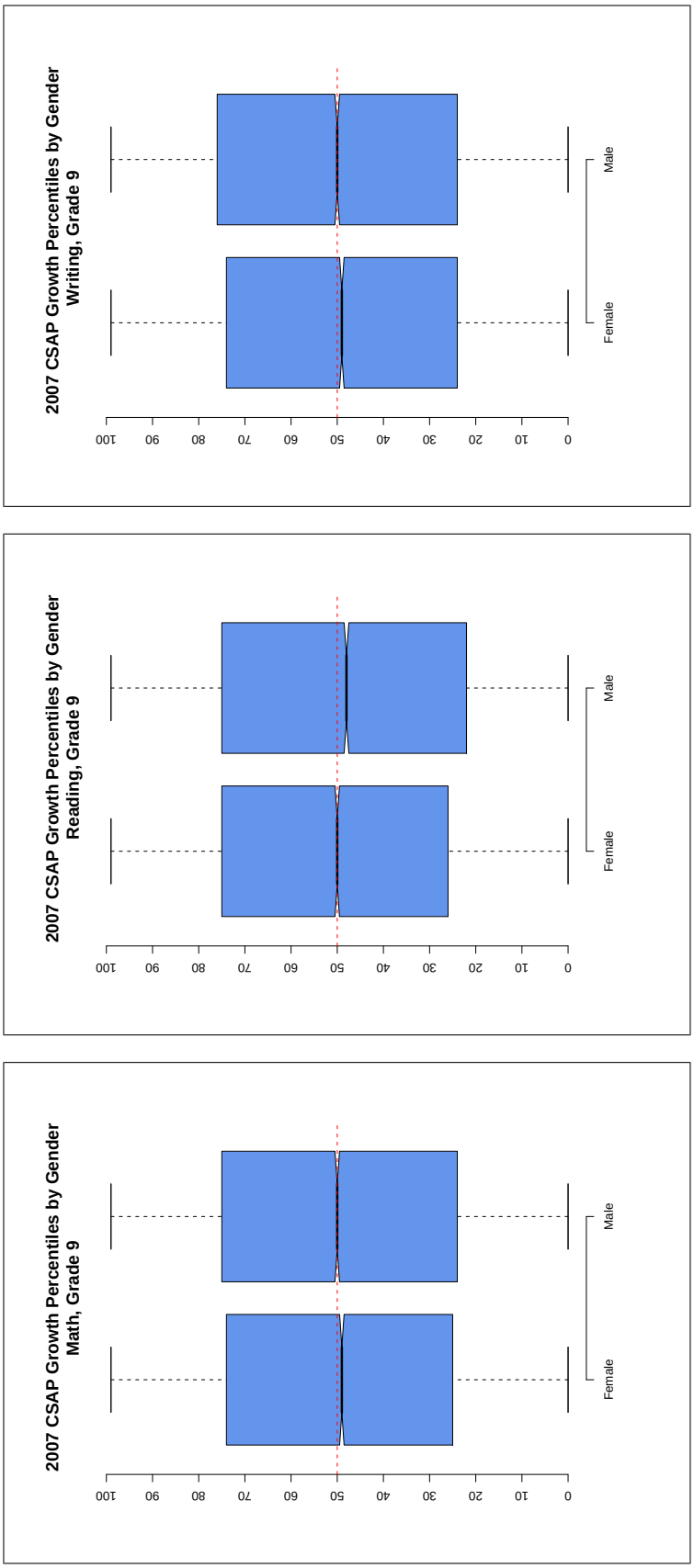

Figure 15: Boxplots of student growth percentiles by gender for 2007 grade 9 math, reading, and writing

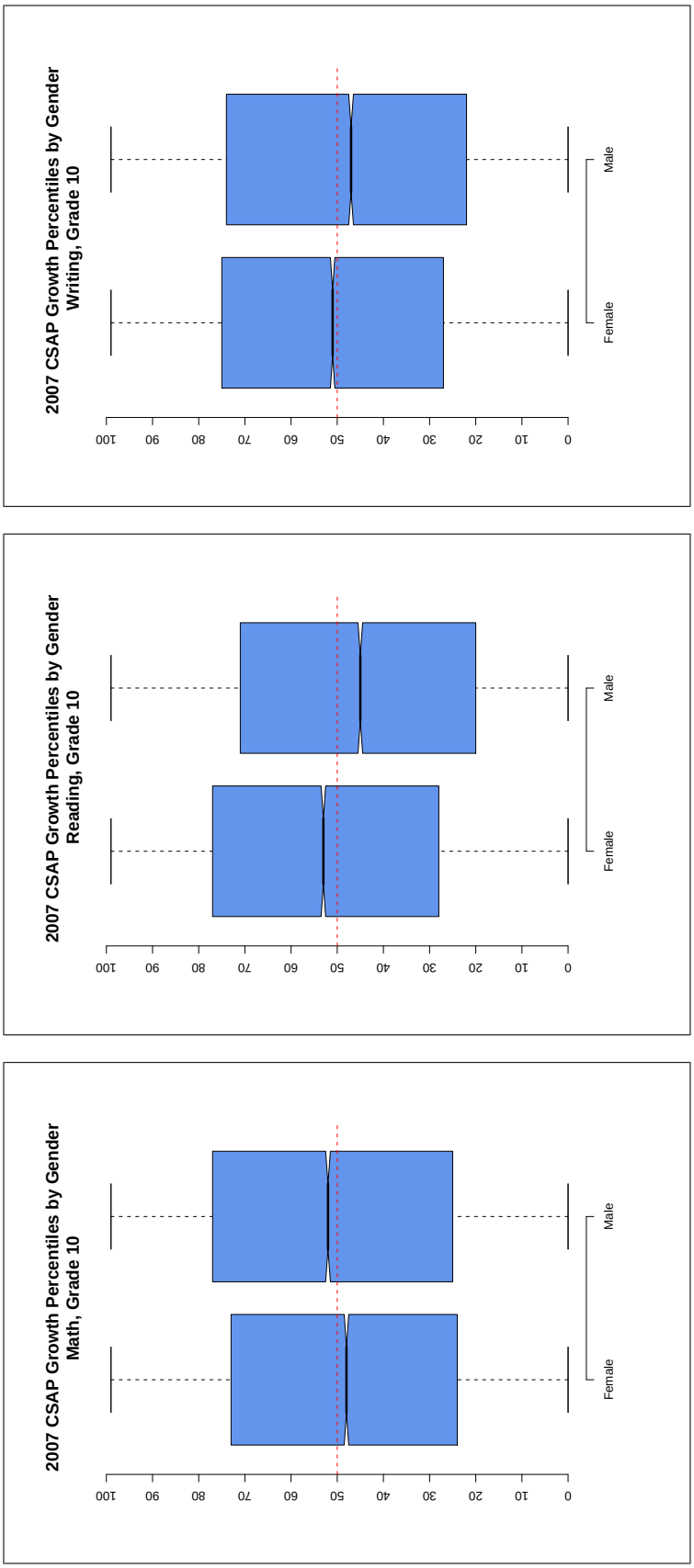

Figure 16: Boxplots of student growth percentiles by gender for 2007 grade 10 math, reading, and writing

Text of HB 07-1048

NOTE: This bill has been prepared for the signature of the appropriate legislative officers and the Governor. To determine whether the Governor has signed the bill or taken other action on it, please consult the legislative status sheet, the legislative history, or the Session Laws.

HOUSE BILL 07-1048

BY REPRESENTATIVE(S) Merrifield, Balmer, Benefield, Borodkin, Butcher, Carroll M., Carroll T., Casso, Fischer, Frangas, Gallegos, Gardner C., Green, Hicks, Hodge, Jahn, Kefalas, Kerr A., Labuda, Lambert, Levy, Madden, Massey, May M., McFadyen, McGihon, Mitchell V., Peniston, Primavera, Rice, Riesberg, Romanoff, Solano, Soper, Stephens, Summers, Todd, and White;
also SENATOR(S) Windels, Bacon, Boyd, Fitz-Gerald, Gordon, Groff, Harvey, Isgar, Keller, Mitchell S., Morse, Penry, Romer, Sandoval, Schultheis, Schwartz, Shaffer, Tapia, Tochtrop, Tupa, Veiga, Ward, Wiens, and Williams.

CONCERNING LONGITUDINAL ANALYSIS OF STUDENT ASSESSMENTS.

Be it enacted by the General Assembly of the State of Colorado:

SECTION 1. Legislative declaration. (1) The general assembly hereby finds and declares that:

(a) Since 1997, the general assembly has directed the department of education to develop the tools and expertise necessary to perform longitudinal analysis of student assessment results and to provide diagnostic information to assist school districts, schools, teachers, and parents in improving students' academic achievement and closing the achievement

Capital letters indicate new material added to existing statutes; dashes through words indicate deletions from existing statutes and such material not part of act.

gap;

(b) The general assembly has demonstrated a high interest in longitudinal analysis of student assessment results based on legislation passed and appropriations made annually since 2001.

(c) Colorado has the opportunity to apply by February 2007 to the United States department of education for flexibility in incorporating longitudinal growth models in the determination of adequate yearly progress under the requirements of the federal "No Child Left Behind Act of 2001", Pub.L. 107-110;

(d) While it is acknowledged that the department of education's inability to spend resources is in part due to the off-budget funding mechanism that makes it difficult to expend dollars until halfway through the fiscal year.

(e) House Bill 07-1048 can be implemented using the existing resources and full-time equivalent employees appropriated to the department of education for fiscal year 2006-07 for development and implementation of a longitudinal growth model.

SECTION 2. 22-7-604.3, Colorado Revised Statutes, is amended to read:

22-7-604.3. Academic growth calculation - model - rule-making. (1) **Legislative declaration.** (a) The general assembly hereby finds, determines, and declares that:

(I) In 1993, the general assembly adopted House Bill 93-1313, establishing state model content standards in several areas, including reading, writing, and mathematics, and directing school districts to adopt district standards in these areas;

(II) The state model content standards were designed to measure what each child should know and be able to do at various levels of development in the child's academic career;

(III) In 1997, Colorado began implementing the Colorado student assessment program to measure whether students were successfully meeting

the state model content standards;

(III.5) SINCE 1997, THE GENERAL ASSEMBLY HAS DIRECTED THE DEPARTMENT TO DEVELOP THE TOOLS AND EXPERTISE NECESSARY TO PERFORM LONGITUDINAL ANALYSIS OF STUDENT ASSESSMENT RESULTS, AND TO PROVIDE INFORMATION TO ASSIST SCHOOL DISTRICTS, SCHOOLS, TEACHERS, AND PARENTS IN IMPROVING STUDENTS' ACADEMIC ACHIEVEMENT AND CLOSING THE ACHIEVEMENT GAP. HOWEVER, DESPITE THE PROVISION OF STATE FUNDING AND CLEAR STATUTORY DIRECTION BY THE GENERAL ASSEMBLY, THE DEPARTMENT HAS NOT YET TAKEN THE STEPS NECESSARY TO MAKE LONGITUDINAL DATA USEFUL TO STUDENTS, PARENTS, TEACHERS, OR ADMINISTRATORS AT THE SCHOOL LEVEL.

(IV) A next step in ~~implementing content standards in education is to identify how much academic growth is required to meet each level of content standard and to measure whether students are achieving this growth~~ MEASURING STUDENT PROGRESS IN MEETING THE STATE MODEL CONTENT STANDARDS IS TO INCORPORATE A LONGITUDINAL GROWTH COMPONENT THAT INDICATES HOW MANY AND WHICH STUDENTS MAKE AT LEAST A YEAR'S ACADEMIC GROWTH IN A YEAR'S TIME, WHILE ALSO IDENTIFYING HOW MANY AND WHICH STUDENTS ARE ON PACE TO BE PARTIALLY PROFICIENT, PROFICIENT, OR ADVANCED, DEPENDING ON THE STUDENTS' STARTING LEVELS, WITHIN THE NEXT THREE YEARS;

(IV.3) THIS INFORMATION ON THE LONGITUDINAL GROWTH OF STUDENTS SHOULD BE THE CORNERSTONE OF THE STATE'S EDUCATIONAL ACCOUNTABILITY SYSTEM;

(IV.7) SCHOOLS AND THE PUBLIC WILL BE BEST SERVED BY A SCHOOL ACCOUNTABILITY SYSTEM THAT IS BASED ON LONGITUDINAL GROWTH, PROVIDES CONSISTENT INFORMATION, AND ENCOURAGES AND SUPPORTS TEACHERS IN MEETING THE NEEDS OF ALL STUDENTS;

(V) The goal for most students, no matter where a student starts, is to achieve yearly academic growth sufficient to perform at least at the proficiency level of "proficient" in reading, writing, and mathematics by the time the student completes grade ten. In the case of students who have not yet completed grade ten but who are performing at the proficiency level of "proficient" or "advanced" in reading, writing, or mathematics on CSAP assessments administered at their respective grades, the goal for such

students is to advance from year to year in a way that maintains or improves upon their proficiency level performance.

(V.3) A LONGITUDINAL GROWTH COMPONENT THAT HAS UNIVERSAL PROFICIENCY FOR STUDENTS AS ITS AIM IS CRITICAL TO A SCHOOL ACCOUNTABILITY SYSTEM BECAUSE IT ARTICULATES A MEANINGFUL GOAL FOR EACH STUDENT REGARDLESS OF THE CURRENT LEVEL OF PERFORMANCE FOR THAT STUDENT;

(V.5) A LONGITUDINAL GROWTH COMPONENT SHOULD MEASURE GROWTH TOWARD A STANDARD AND DETERMINE THE AMOUNT OF GROWTH A STUDENT IS MAKING TOWARD PARTIALLY PROFICIENT, PROFICIENT, AND ADVANCED PERFORMANCE. OTHER CHARACTERISTICS OF A HIGH-QUALITY LONGITUDINAL GROWTH COMPONENT SHOULD INCLUDE:

(A) IDENTIFYING HOW MANY AND WHICH STUDENTS WHO ARE NOT YET PROFICIENT ARE ON PACE TO BECOME PROFICIENT;

(B) IDENTIFYING HOW MANY AND WHICH STUDENTS WHO ARE PROFICIENT ARE ON PACE TO REMAIN PROFICIENT; AND

(C) IDENTIFYING HOW MANY AND WHICH STUDENTS WHO ARE ALREADY PROFICIENT OR ADVANCED ARE ON PACE TO MOVE UP ON THE ADVANCED END OF THE ACHIEVEMENT DISTRIBUTION.

(V.7) ANOTHER ASPECT OF A HIGH-QUALITY LONGITUDINAL GROWTH COMPONENT WILL BE THE ABILITY TO PROVIDE RELIABLE, VALID, AND MEANINGFUL RESULTS TO EXTERNAL STAKEHOLDERS TO ENABLE THEM TO JUDGE ACADEMIC IMPROVEMENT AND HOLD THE EDUCATIONAL SYSTEM ACCOUNTABLE;

(VI) WITH A LONGITUDINAL GROWTH MODEL IN PLACE, the numeric CSAP scores received by each student in successive school years ~~can be used to provide a diagnostic measure that~~ will indicate the student's degree of academic growth over time;

(VII) Measuring each student's academic growth over time will provide necessary ~~diagnostic~~ information to assist parents, teachers, schools, and school districts in identifying students who need additional assistance and will help to close the learning gap that sometimes exists

among students in the same classrooms;

(VIII) The ~~diagnostic~~ measurement of student academic growth over time should be based upon all available individual scores for the student on statewide assessments administered to the student through the years; and

(IX) The ~~diagnostic~~ methodology of calculating student academic growth over time should be capable of accommodating the inclusion of all students, including students for whom sparse data is available.

(b) The general assembly further finds and declares that:

(I) Efforts to improve student academic growth should emphasize closing achievement gaps;

(II) A true longitudinal measure is required that tracks individual students from one grade level in the first year to the next higher grade level in the following year and that accommodates students retained in grade;

(III) Only students who were enrolled in a school by October 1 of the school year should have their academic growth included in the school's overall academic growth rating for that school year in the school accountability report;

(IV) An academic growth measurement should account for the influence of artificially high- or low-scoring students and regression toward the mean;

(V) Credit should be given for students who maintain their performance at the advanced level of proficiency, even if their scale scores decline, to recognize the substantial amount of learning required to maintain that level of performance and to avoid penalizing schools with large numbers of advanced-level students whose scores might decline slightly due to measurement error;

(V.5) AN ACADEMIC GROWTH MEASUREMENT WILL SET THE PROPER TENSION BY FOCUSING ATTENTION ON ALL STUDENTS. AN ACADEMIC GROWTH MEASUREMENT WILL NOT ONLY DEFINE WHAT CONSTITUTES A YEAR'S ACADEMIC GROWTH IN A YEAR'S TIME BUT IT WILL IDENTIFY HOW MANY AND WHICH STUDENTS MAKE A YEAR'S ACADEMIC GROWTH IN A

YEAR'S TIME, WHILE ALSO PROVIDING USEFUL INFORMATION ON EACH STUDENT WITH RESPECT TO THE PROVISIONS OF SUBPARAGRAPH (V.5) OF PARAGRAPH (a) OF THIS SUBSECTION (1).

(VI) An academic growth measurement should ~~measure~~ GAUGE each student's progress toward performing at the proficiency level of "advanced" or "proficient";

(VII) An academic growth measurement should measure the performance over time of students assigned to specific classrooms and teachers; and

(VIII) Teachers should be able to identify individual students who are not making sufficient progress and to use the ~~diagnostic~~ properties of CSAP's objectives to plan instructional strategies for improvement.

(c) Therefore, it is the intent of the general assembly to adopt legislation to implement a process for ~~diagnostically~~ measuring student academic growth and to include a longitudinal student academic growth measurement on the school accountability report that will:

(I) Create a cooperative atmosphere among students, parents, teachers, school district administrators, the department of education, and the state board of education; and

(II) Promote the highest possible academic achievement FOR ALL STUDENTS, INCLUDING MOVING STUDENTS FROM UNSATISFACTORY TO PARTIALLY PROFICIENT, PARTIALLY PROFICIENT TO PROFICIENT, AND PROFICIENT TO ADVANCED, AND ENSURING STUDENTS WHO SCORE ADVANCED CONTINUE TO SCORE ADVANCED.

(2) **Development of model - technical advisory panel.** (a) Within fifteen days after ~~June 3, 2004~~ RECEIPT OF THE RECOMMENDATIONS OF THE TECHNICAL ADVISORY PANEL PURSUANT TO SUBPARAGRAPH (I) OF PARAGRAPH (b) OF THIS SUBSECTION (2), the department shall choose ~~a~~ AN EXPERIENCED public or private entity, ~~to develop,~~ WITH A STRONG NATIONAL REPUTATION, TO REVISE THE LONGITUDINAL GROWTH MODEL DEVELOPED PRIOR TO JANUARY 1, 2007, PURSUANT TO SUBSECTION (3) OF THIS SECTION TO ENSURE THAT IT IS APPROPRIATE FOR DESIGNATING LONGITUDINAL GROWTH ACHIEVEMENT FOR INDIVIDUAL SCHOOLS AND THAT IT CONSIDERS

STATE LONGITUDINAL GROWTH MODELS APPROVED BY THE UNITED STATES DEPARTMENT OF EDUCATION. No later than ~~June 15, 2004 a~~ SIXTY DAYS AFTER BEING CHOSEN, THE CONTRACTOR SHALL ADAPT AN EXISTING mixed-effects statistical model FOR USE IN COLORADO to ~~diagnostically~~ calculate students' annual academic growth and to calculate annually the amount of each student's and each school's academic growth in reading, writing, and mathematics over the periods between the administration of the CSAP assessments, which calculation shall be based on students' CSAP scores.

(a.5) THE CONTRACTOR CHOSEN PURSUANT TO PARAGRAPH (a) OF THIS SUBSECTION (2) SHALL UTILIZE A MODEL IN THE PUBLIC DOMAIN THAT IS NOT PROPRIETARY AND IS FULLY AND ACCURATELY EXPLAINED, INCLUDING THE GENERATION OF ALL RESULTS, IN A PUBLISHED DOCUMENT THAT IS AVAILABLE TO THE PUBLIC. THE MODEL THAT THE CONTRACTOR GENERATES SHALL BE ONE THAT CAN BE REPLICATED BY ANY INDEPENDENT STATISTICIAN. INCLUDED IN THE SCOPE OF WORK FOR THE CONTRACTOR SHALL BE THE EXTENSION OF THE LONGITUDINAL GROWTH CALCULATION DEVELOPED PURSUANT TO THIS SECTION TO THE SCHOOL LEVEL WITH THE INTENT THAT IT BE THE BASIS FOR ALL ACADEMIC ACCOUNTABILITY.

(b) (I) No later than ~~June 15, 2004~~ FIFTEEN DAYS AFTER THE EFFECTIVE DATE OF HOUSE BILL 07-1048, the GOVERNOR SHALL APPOINT AND THE department shall convene a technical advisory panel that ~~includes~~ SHALL INCLUDE STATE AND NATIONAL experts on the measurement of longitudinal growth for accountability purposes. ALL MEETINGS OF the technical advisory panel shall be open.

(II) AT IT'S FIRST MEETING, THE TECHNICAL ADVISORY PANEL SHALL RECOMMEND TO THE DEPARTMENT ONE OR MORE CONTRACTORS TO ADAPT A STATISTICAL MODEL PURSUANT TO PARAGRAPH (a) OF THIS SUBSECTION (2). THE TECHNICAL ADVISORY PANEL SHALL review the proposed model developed pursuant to paragraph (a) of this subsection (2) for ~~diagnostically~~ calculating the annual academic growth of students AND SCHOOLS. The model, at a minimum, shall specify the standard error of measurement and shall specify the stringency of the confidence interval used to determine whether the annual change in test scores can be attributable to chance due either to measurement error or to regression to the mean. In reviewing the model, the TECHNICAL advisory panel shall consider recent national studies of different methodologies and VARIOUS models for measuring longitudinal

growth, INCLUDING LONGITUDINAL GROWTH MODELS THAT THE UNITED STATES DEPARTMENT OF EDUCATION HAS APPROVED FOR USE BY STATES AS PART OF STATE PLANS TO MEET THE ADEQUATE YEARLY PROGRESS REQUIREMENTS OF THE FEDERAL "NO CHILD LEFT BEHIND ACT OF 2001", PUB.L. 107-110.

(c) No later than ~~July 1, 2004~~ THIRTY DAYS AFTER THE ADAPTATION OF THE MODEL PURSUANT TO THIS SUBSECTION (2), the TECHNICAL ADVISORY panel convened pursuant to paragraph (b) of this subsection (2) shall submit its written ~~comments or~~ FINDINGS AND recommendations CONCERNING THE LONGITUDINAL GROWTH MODEL to the department, the state board, the education committees of the senate and the house of representatives, OR ANY SUCCESSOR COMMITTEES, and the governor. THE DEPARTMENT SHALL MAKE THE FINDINGS AND RECOMMENDATIONS ELECTRONICALLY AVAILABLE TO THE PUBLIC AND SHALL PROMPTLY NOTIFY PERSONS WHO REQUEST NOTICE OF WHEN AND WHERE TO OBTAIN THE ELECTRONIC COPIES OF THE FINDINGS AND RECOMMENDATIONS.

(d) The department shall convene the panel described in paragraph (b) of this subsection (2) within existing appropriations.

(3) **Academic growth calculation model.** (a) On or before ~~August 15, 2004~~ THIRTY DAYS AFTER THE RECEIPT OF THE RECOMMENDATIONS OF THE TECHNICAL ADVISORY PANEL PURSUANT TO PARAGRAPH (c) OF SUBSECTION (2) OF THIS SECTION, the state board shall consider the model developed pursuant to subsection (2) of this section and ~~reviewed by~~ THE FINDINGS AND RECOMMENDATIONS OF the technical advisory panel and shall adopt by EMERGENCY rule a mixed-effects statistical model used to ~~diagnostically~~ calculate ~~students'~~ THE annual academic growth OF STUDENTS AND SCHOOLS that shall be a scientifically rigorous statistical model available in the public domain. AFTER THE PROMULGATION OF THE EMERGENCY RULE, THE STATE BOARD SHALL PROMULGATE PERMANENT RULES ON ADOPTING THE STATISTICAL MODEL. The state board may adopt a hierarchical linear model as the statistical model OR SOME VARIATION OF SUCH A MODEL.

(b) The state board, in adopting the statistical model described in paragraph (a) of this subsection (3), shall ensure that the model:

(I) Reflects best practices, as acknowledged in the scientific

literature, in measuring longitudinal growth with high precision;

(II) To the greatest extent possible, uses a methodology that will serve the ~~diagnostic~~ purposes of SCHOOLS AND school districts; ~~and schools;~~

(III) Is capable of measuring how much progress a student is making toward performing at the proficiency level of "PARTIALLY PROFICIENT", "proficient", or "advanced" on CSAP assessments;

(III.5) IS CAPABLE OF GAUGING HOW SUCCESSFUL EACH STUDENT WILL BE IN MAKING ONE YEAR'S ACADEMIC GROWTH IN ONE YEAR'S TIME;

(IV) Provides results that are meaningful, reliable, and valid, given their intended purposes, to enable parents, teachers, and administrators to identify individual students or groups of students who ARE AND are not making sufficient academic growth;

(IV.5) RECOGNIZES IMPROVEMENT OF STUDENTS WHOSE SCALE SCORES INCREASE EVEN IF THEY DO NOT INCREASE TO A HIGHER CSAP PERFORMANCE LEVEL;

(V) Uses individual student scores from CSAP assessments;

(VI) Is described in a publicly available document that ~~describes~~ SETS FORTH the mathematical equations used in the statistical model and that ~~describes~~ FULLY AND ACCURATELY EXPLAINS the methods used to complete the records for students with incomplete data; and

(VII) Is capable of treating the analysis and reporting of data electronically AND PRODUCES STUDENT- AND SCHOOL-LEVEL REPORTS THAT MAY BE DELIVERED ON OR BEFORE SEPTEMBER 15, 2007, AND ON OR BEFORE SEPTEMBER 15 OF EACH YEAR THEREAFTER.

(4) **Adequate academic growth.** (a) No later than ~~September 15, 2004~~ AUGUST 15, 2007, AND NO LATER THAN AUGUST 15 EACH YEAR THEREAFTER, the department shall calculate what constitutes ~~sufficient~~ ADEQUATE LONGITUDINAL academic growth for each student for each school year. The department shall formulate the calculation in such a way that ~~sufficient~~ ADEQUATE LONGITUDINAL academic growth means:

(I) A student is progressing ~~sufficiently~~ ADEQUATELY to perform in reading, writing, and mathematics at increasing levels of proficiency, projected at grade levels determined by the department, in consultation with the technical advisory panel, with the goal of performance at least at the proficiency level of "proficient" before completing grade ten; and

(II) For a student who is performing at the proficiency level of "advanced", the student is progressing from year to year in a way that maintains or improves upon the student's proficiency level performance.

(b) The department shall use data available for longitudinal analysis to review and revise the calculation of academic growth as necessary.

(5) **Academic growth information - rule-making.** (a) Beginning in the ~~2004-05~~ 2007-08 school year, the department shall provide to each school district in the state ~~diagnostic~~ academic growth information for each student enrolled in the school district and for each public school in each school district, based on the CSAP assessment results for the preceding school years.

(b) Beginning in the ~~2004-05~~ 2007-08 school year, the department shall provide to each charter school in the state ~~diagnostic~~ academic growth information for each student enrolled in the charter school, based on the CSAP assessment results for the preceding school years. The department shall ensure that data provided to a charter school pursuant to this paragraph (b) include only the data for students enrolled in the charter school.

(b.5) THE ACADEMIC GROWTH INFORMATION REQUIRED BY PARAGRAPHS (a) AND (b) OF THIS SUBSECTION (5) SHALL INCLUDE INFORMATION ON WHETHER EACH STUDENT MADE AT LEAST ONE YEAR'S ACADEMIC GROWTH IN ONE YEAR'S TIME AND WHETHER THE AMOUNT OF ACADEMIC GROWTH IS ADEQUATE FOR THE STUDENT TO REACH A PERFORMANCE LEVEL OF PROFICIENT WITHIN THREE YEARS OR BY GRADE TEN, WHICHEVER COMES SOONER. FOR STUDENTS WHO ARE ALREADY PROFICIENT, THE ACADEMIC GROWTH INFORMATION SHALL SPECIFY WHETHER THE STUDENT IS ON PACE TO REMAIN PROFICIENT OR WHETHER THE STUDENT IS ON PACE TO MOVE INTO THE UPPER RANGE OF THE ACHIEVEMENT DISTRIBUTION; EXCEPT THAT A DIFFERENT INTERVAL MAY BE SELECTED BY THE DEPARTMENT IF RECOMMENDED BY THE TECHNICAL ADVISORY PANEL.

(c) Repealed.

(d) ~~The state board shall promulgate rules establishing the procedures by and time frames in which the department shall provide the diagnostic academic growth information to school districts and to charter schools pursuant to this subsection (5). The department may provide the diagnostic academic growth information in an electronic format.~~

(e) The department and school districts shall maintain the confidentiality of each student's CSAP scores consistent with the federal "Family Educational Rights and Privacy Act of 1974", 20 U.S.C. sec. 1232g, and all federal regulations and applicable guidelines adopted in accordance therewith.

(f) The ~~diagnostic~~ academic growth information provided by the department shall be included in each student's individual student record maintained by the school district in which the student is enrolled.

(g) The general assembly hereby finds that preparation and provision of ~~diagnostic~~ academic growth information constitutes accountable education reform and may therefore be funded from moneys in the state education fund created in section 17 (4) of article IX of the state constitution.

(h) The department shall provide technical assistance and training to school districts and charter schools to assist school district and charter school personnel in interpreting and using the ~~diagnostic~~ academic growth information provided pursuant to this subsection (5). The costs of providing technical assistance and training pursuant to this paragraph (h) shall be paid BY THE DEPARTMENT within existing appropriations for implementation of this section.

(6) **Rule-making.** The state board is authorized to promulgate any rules necessary to calculate annual ~~diagnostic~~ LONGITUDINAL academic growth.

(7) **Academic growth information - research.** The department, upon request, shall make available to qualified researchers the entire longitudinally linked dataset created pursuant to this section and used for generating ~~diagnostic~~ ACADEMIC growth information and for awarding the

governor's distinguished improvement awards. For purposes of this subsection (7), qualified researchers shall include, but need not be limited to, institutions of higher education, school districts, and public policy research and advocacy organizations. The department shall provide the information in a format that allows it to be linked with other publicly available data in the state and shall include all available data regarding student demographics, the state's school identification numbers, and student-level performance data, while protecting the privacy of individual students in a manner consistent with the federal "Family Educational Rights and Privacy Act of 1974", 20 U.S.C. sec. 1232g, and all federal regulations and applicable guidelines adopted in accordance therewith.

SECTION 3. 22-11-305 (1), Colorado Revised Statutes, is amended to read:

22-11-305. Governor's distinguished improvement awards - repeal. (1) (a) The state board shall annually present financial awards to the public schools in the state demonstrating the highest rate of student academic growth. The technical advisory panel convened pursuant to section 22-7-604.3 (2) (b) shall recommend to the state board and the state board shall establish by rule the method by which to identify schools that demonstrate the highest rate of student academic growth in a school year toward state standards for proficiency. The technical advisory panel shall take school size into account in preparing its recommendations.

(b) (I) AS SOON AS PRACTICABLE AFTER THE ADOPTION OF THE MIXED-EFFECTS STATISTICAL MODEL PURSUANT TO 22-7-604.3 (3) (a), THE TECHNICAL ADVISORY PANEL SHALL RECOMMEND TO THE STATE BOARD AND THE STATE BOARD SHALL BY RULE ESTABLISH A NEW METHOD TO IDENTIFY SCHOOLS THAT DEMONSTRATE THE HIGHEST RATE OF ACADEMIC GROWTH BASED UPON THE MIXED-EFFECTS STATISTICAL MODEL. SUBJECT TO AVAILABLE APPROPRIATIONS, UNTIL THE ADOPTION OF RULES PURSUANT TO THIS SUBPARAGRAPH (I), THE DEPARTMENT SHALL CONTINUE TO PRESENT HONORARY OR FINANCIAL AWARDS PURSUANT TO THIS SECTION UNDER THE RULES EXISTING AS OF JANUARY 1, 2007.

(II) THIS PARAGRAPH (b) IS REPEALED, EFFECTIVE JULY 1, 2009.

SECTION 4. Repeal. 22-54-114 (2.5), Colorado Revised Statutes, is repealed as follows:

22-54-114. State public school fund. (2.5) ~~The general assembly finds that implementation of section 22-7-603.5, including implementation of rules to uniquely identify individual students, has resulted in more accurate determinations of pupil enrollment and a savings in the amount required to fund the state's share of total program funding for school districts and institute charter schools. For the 2003-04 budget year and budget years thereafter, the department of education shall allocate a portion of the amount of the in-year cost recovery occurring as a result of the use of unique student identifiers to fund implementation of section 22-7-604.3, concerning the calculation of academic growth of students for diagnostic purposes. The amount allocated for the implementation of section 22-7-604.3 shall not exceed two hundred thousand dollars in any budget year.~~

SECTION 5. Safety clause. The general assembly hereby finds,

determines, and declares that this act is necessary for the immediate preservation of the public peace, health, and safety.

Andrew Romanoff SPEAKER OF THE HOUSE OF REPRESENTATIVES	Joan Fitz-Gerald PRESIDENT OF THE SENATE
Marilyn Eddins CHIEF CLERK OF THE HOUSE OF REPRESENTATIVES	Karen Goldman SECRETARY OF THE SENATE

APPROVED_____

Bill Ritter
GOVERNOR OF THE STATE OF COLORADO

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