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The Predictive Validity of Mathematics Curriculum-Based Measurement on Smarter Balanced Assessment Consortium Mathematics Scores

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Abstract

The purpose of this study was to examine the predicative validity of computation curriculum-based measurement (CBM) on mathematics Smarter Balanced Assessment Consortium scores (SBAC). This study looked at one cohort consisting of 2,741 participants in third, fourth, and fifth grade during the 2017-2018 school year in one school district in Oregon. This study used a hierarchical multiple regression to examine the relationship between CBM and mathematics SBAC. Additionally, this study looked at the extent to which gender, ethnicity, special education status (SPED) and English language learner (ELL) status interacted with CBM scores to predict end-of-year mathematics SBAC scores. The findings of this study indicate that CBM scores predict math SBAC scores in third, fourth, and fifth grade to a modest extent. The findings also indicate that taken together, CBM scores, gender, ethnicity, special education status, and English language learner status predict math SBAC scores to a moderate extent.

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Chapter 1: Introduction

The National Center for Education Statistics (2018) reports that in 2017, only 40% of U.S. fourth-graders were considered proficient in mathematics. This problematic statistic means that well over half the nation's fourth graders are not meeting standards for proficiency in mathematics. During the 2017-2018 school year 55% of third graders, 56.5% of fourth graders, and 49.8% of fifth graders in the Elk Ridge School District (pseudonym) were considered proficient, earning a level three or four, on the Smarter Balanced Assessment Consortium mathematics assessment (Oregon Department of Education, 2018). The Oregonian reported the following:

> In the four years that Oregon's students have taken the nationally benchmarked Smarter Balanced tests covering reading, writing and math, performance has never been worse in math than it was this year. The tests are designed to measure whether students have the skills they need to be on track for college and careers. They were vetted by college professors, teachers, curriculum experts and employers, who said they indeed measure the skills that U.S. school students need to be successful in higher education and the workplace (Hammond, 2018).

The Common Core State Standards (CCSS) say that by the end of third grade, students should, "fluently multiply and divide within 100…know from memory all products of two one-digit numbers" (Common Core State Standards Initiative, 2018a). Fourth- and fifth-grade standards build on and extend this standard. The National Mathematics Advisory Panel (2008) recommends an emphasis on proficiency of key topics at the elementary level. Proficiency, the panel claims, includes both understanding and automaticity. The time is now for policymakers, educators, and parents to craft ways to identify students struggling in mathematics so that

effective interventions can be implemented and students can begin to meet benchmark standards in this important area of the curriculum.

Problem Statement

The fact that a significant percentage of elementary students are lacking essential mathematics skills is concerning. In 2017, only 33 percent of fourth graders scored at or above proficiency level in mathematics according to the National Assessment for Educational Progress (NAEP, 2017a). District wide, 54.4 percent of students in grades 3 through 5 were considered proficient on the Smarter Balanced Assessment Consortium (SBAC) mathematics test (ODE, 2017a). This study attempted to address this problem by examining computation curriculum-based measurement (CBM) as a potential tool for predicting student performance on the SBAC.

Purpose

The purpose of this study was three-fold, first to investigate the predictive validity of third-, fourth-, and fifth-grade math computation curriculum-based measurement (CBM) as predictors of third-, fourth-, and fifth-grade Smarter Balanced Assessment Consortium (SBAC) mathematics scores in the Elk Ridge School District in Oregon. Second, this study investigated the extent to which gender interacts with CBM scores to predict SBAC mathematics scores in third, fourth, and fifth grade in the Elk Ridge School District in Oregon. Finally, this study explored the extent to which additional demographic factors including ethnicity, special education status, and English language learner (ELL) status interacted with CBM scores to predict SBAC mathematics scores in third, fourth, and fifth grade in the Elk Ridge School District in Oregon.

The purpose of looking at the predictive validity of a universal screening measure (CBM) on SBAC is to determine the usability for educators of CBM in helping to build a case, as one

piece of evidence in combination with classroom data, for individuals needing intervention.

What is a CBM?

CBM, or curriculum-based measurement, was created in the early 1970's at the University of Minnesota. CBM has been designed not only in the area of math computation, the focus of this study, but also in the areas of reading, writing, spelling, science, and social studies. CBMs are short, timed assessments. Currently CBMs are used to give teachers a baseline for student performance, but not to help establish who might benefit from extra support. The CBMs used in this study measured students' proficiency in multiplication and division. Lembke and Stecker (2007) say:

> Administration time for each measure ranges from one to eight minutes, and these measures serve as indicators of academic performance in that as students' achievement in mathematics increases, there is subsequent growth on the mathematics CBM probes. The measures are timed to give teachers a quick snapshot of student performance. (p. 2-3).

For examples of third- through fifth-grade math computation CBMs, see Appendices A-D.

Research Questions

This study explored three research questions:

1. To what extent do mathematics curriculum-based measurements taken in the fall predict mathematics SBAC scores taken at the end of year for students in third, fourth, and fifth grade?
2. To what extent does gender interact with mathematics CBM scores to predict mathematics SBAC scores?
3. To what extent do mathematics curriculum-based measurements taken in the fall, together with demographic factors for ethnicity, special education status, and English

language learner (ELL) status predict mathematics SBAC scores taken at the end of year in the third, fourth, and fifth grades?

Rationale

The National Council of Teachers of Mathematics believes mathematical proficiency is built on the critical component of procedural fluency (NCTM, 2014a). Procedural fluency is defined by the NCTM (2014b) as:

> …the ability to apply procedures accurately, efficiently, and flexibly; to transfer procedures to different problems and contexts; to build or modify procedures from other procedures; and to recognize when one strategy or procedure is more appropriate to apply than another. (p.1).

Mathematical proficiency in the elementary years is of concern in the United States. Considering the bleak picture painted by the findings of the 2017 National Assessment for Education Progress, 2017 SBAC scores, and the National Center for Education Statistics, proficiency in mathematics at the elementary level is low. This study will add to the needed research literature that can shed light on how educators might make needed improvement in this critical area of the curriculum. Classroom teachers, administrators, and districts need quick and easy assessment tools, given early in the school year, to assess for potential mathematics proficiency issues in order to provide effective interventions before end-of-year summative assessments. This study explored whether math computation CBMs could be such a tool.

While CBM has been used since the 1970's to measure student growth, more research is needed to establish broader use of math CBM (Christ, Scullin, Tolbize, & Jiban, 2008). Recent research also calls for additional studies on gender differences in performance on CBMs (Yarbrough, Cannon, Bergman, Kidder-Ashley, & McCane-Bowling, 2017). In their 2015 study,

Chafin et al. suggest that researchers "…continue to add to the body of research on using mathematics CBM as a means to predict student performance on state mathematics assessments" (p. 36). Lembke and Stecker (2007) report, "states or districts might choose to examine the relationship between CBM measures and their state standards or high stakes outcomes, but this would be an individual state decision" (p. 12).

Proficiency in mathematics, as defined by achieving a level 3 or 4 on SBAC, declines between third and fourth grade and again between fourth and fifth grade in the state of Oregon. For the 2015-2016 school year, 46% of third graders were considered proficient in SBAC math, for fourth graders it dropped to 43%, and for fifth graders only 39% were proficient (Oregon Department of Education, 2017b). This decline points to a need for students to be identified and receive effective, timely interventions.

Rationale for the choice of CBM and SBAC for this study. CBMs are used by many districts both in Oregon and across the country. They are a relatively inexpensive, easy-to-use assessment. CBM assessments can be given in a matter of minutes, and are quick to score. CBMs are given early in the year, making them a strong choice for building a case for intervention before too much of the school year has passed. In discussing the creation of CBM, Deno (1985) noted that the original team of researchers set out to create a tool that met a certain set of requirements: the tool had to be reliable and valid, simple and efficient, easily understood, and inexpensive. CBMs provide a quick snapshot of student ability on a simple computation measure.

SBAC is currently given in 13 states (Regents of the University of California, 2018c). It is a testing measure that was created in response to the Race to the Top initiative put forth by the Obama administration. The aim of SBAC creation was to design an assessment that would be a

match for the common core state standards (CCSS). Being a measure that is administered widely, has been tested for reliability and validity, assesses depth and breadth of the CCSS, and is used by teachers, administrators, districts, and policy makers in large-scale decisions, it made sense to use SBAC for this study. The first administration of SBAC in a student's academic career is at the end of their third-grade year. This study looks at the elementary administration of SBAC for third through fifth grades.

DIBELS as an example. Literacy and mathematics are the central focus of elementary instruction. It may be that the principles used to identify students for intervention in literacy could be transferred to the area of mathematics. Dynamic Indicators of Basic Early Literacy Skills (DIBELS) was developed at the University of Oregon in the 1980's based on procedures for curriculum-based measurement. DIBELS is based on the same procedures and principles as math CBM, created by Deno and colleagues in the 1970's at the University of Minnesota (Dynamic Measurement Group, 2018). Many school districts, including the Elk Ridge School District, use DIBELS at the start of the year to assess students for reading intervention. If students fall below a certain benchmark, they are given an additional 30 minutes of reading instruction, in addition to the hour and a half of core reading instruction during the school day. Math CBMs could potentially serve the same function for math intervention.

Shaw and Shaw (2002) looked at ORF (oral reading fluency) scores, part of DIBELS, to see if they were predictive of the Colorado State Assessment Program (CSAP). Their study, which focused on third graders, found that fall ORF benchmarks were predictive of end-of-year scores on the CSAP ($r = .73$) (Shaw & Shaw, 2002). In another study of third and fourth graders using ORF and the Ohio Proficiency Test in Reading (OPT), it was found that correlation coefficients were significant ($r = .61$-$.65$) (Vander Meer, Lentz, & Stollar, 2005). Good, Powell-

Smith, Abbott, Dewey, Warnock, &VanLoo (2018) found that DIBELS composite scores, for students in grades three through five, showed a strong correlation to SBAC ELA scores ($r = .70$-$.75$). They found that those students who scored above benchmark on DIBELS were highly likely to meet or exceed on the SBAC ELA measure (Good et al., 2018). If DIBELS can predict SBAC ELA scores, there is potential for math CBMs to predict math SBAC scores.

As with any standardized assessment, there is danger in using a single test score as the sole means for determining a student's ability. However, standardized, universally-taken measures can help educators gain an understanding of a student's baseline abilities, and in conjunction with classroom formative and summative assessment, build a case for students who need extra support.

Significance

This study has the potential to have practical significance in the district in which it is being conducted. If CBMs are predictive of SBAC scores, then CBMs could potentially be used by educators, in conjunction with classroom data, to make a case for students who need additional intervention time. CBMs, taken at the beginning of the school year, could impact intervention decisions with enough time for teachers to help students make progress before end-of-year summative assessments. If CBMs are not predictive of SBAC scores, then math CBMs could be eliminated to relieve testing load. Additionally, if CBMs are not predicative of SBAC, this could be valuable information for teachers when making decisions about how to use CBM scores in their own instruction, and perhaps influence the importance educators assign to CBM scores. Currently, it is up to individual educators to decide how to use CBM scores. The more information educators have about CBMs, such as their predictive validity to SBAC, the more informed decisions educators can make about how best to use CBM scores. If gender differences

do exist, instructional practices to eliminate a gender gap in mathematics should be considered by the district for implementation. Many districts across Oregon, and the nation, use CBMs. This study could potentially add to the literature regarding CBM use and inform classroom practice. Part of classroom practice is identifying struggling students and working to meet their individual needs, often through intervention.

Necessity of Building a Case for Intervention

For students who are not meeting grade-level standards, help beyond what can be offered in the general education classroom setting may be necessary. Once at-risk students have been identified, intervention can be a powerful tool for increasing student skills. Intervention can take many forms including one-on-one intervention, small-group intervention, and technology-mediated intervention. In a synthesis of 19 studies conducted between 2000 and 2016 on the impact of technology-mediated mathematics interventions for students who were at-risk for, or already identified to have, a mathematics learning disability it was found that interventions positively impacted mathematics ability at the elementary level (Kiru, Doabler, Sorrells, Cooc, 2017). In a meta-analysis of 42 studies, it was found that explicit mathematics intervention resulted in gains for students with mathematics learning disabilities (Gersten et al., 2009). Interventions that used explicit instruction were found to be significant having a mean effect size of 1.22 ($p < .001$; range = 0.08 to 2.15) (Gersten et al., 2009). Intervention is not just for those with a mathematical disability. Intervention is also necessary for many general education students. “For many children, mathematical deficits begin early. By the time school starts, mathematical thinking is well underway among children who will demonstrate strong achievement in later grades” (Fuchs, Fuchs, & Karns, 2001, p. 496). Educators have an obligation at the elementary level to identify and support struggling math learners.

Mathematics intervention, when provided early, can restore mathematical deficits and help prevent deficits in the future (Fuchs, Fuchs, & Karns, 2001; Fuchs, Fuchs, Yazdian, & Powell, 2002). The Response to Intervention Action Network, a model used by many districts across the United States, says that 5 percent of children will need targeted individual intervention. The network also says that CBM is helpful for identifying these students (National Center for Learning Disabilities, 2018). Universal screening is recommended for all students, so that those who are at-risk for failure can be identified (Hughes & Dexter, 2014). Early identification and targeted intervention are key to closing the achievement gap.

A Practitioner's Perspective

With limited time, personnel, and money teachers must often build a strong case for a student to receive intervention before intervention can begin. Building a case can include collecting observational data, curriculum assessments, and formative and summative classroom data. Even then it can be difficult to get precious resources to be used for math intervention. Looking at the predictive validity of CBMs on SBAC could help educators make informed decisions about including CBM as a piece of data in building a case for struggling students.

Limitations and Delimitations

One limitation of this study is that SBAC is a relatively new assessment. SBAC was fully implemented in 2015. At the time the participants in this study took SBAC math, the test had only been given for four years. The short time period calls into question issues with validity, reliability, and bias. A second limitation of this study is that parents can opt their students out of taking SBAC. While this choice is uncommon, there are students for whom no SBAC score exists. Students with no SBAC score were not included in the study. This could have a potential

effect on the data. Is there a particular student profile for whom parents are more likely to opt their student out? If so, are those students fairly represented in the sample?

A further limitation could be the administration of both SBAC and CBMs. Both tests are administered by individual educators in the classroom. Before administering SBAC, educators must attend training. Directions for both assessments are provided and are to be read verbatim by the educators. The problem with this is fidelity. The assumption is that educators are administering the tests with integrity, but it cannot be known for sure that the administration experience does not vary from one classroom to the next. Testing environment, including interruptions, may be compromised in some situations.

One delimitation of the current study is that the sample only consists of one school district. This limits generalizability. Predictive validity of CBMs on SBAC scores could only be determined for the population used. Another delimitation is the demographic variables that were used and their coding. For instance, special education status in this study is operationalized as "yes" or "no. Either they qualify or they do not. Special education status is a spectrum and cannot be fully represented by only two categories. SPED qualification represents a continuum of needs. The variables in this study have inherent limitations.

Another delimitation is that this study did not explore the the influences of demographics in combination with one another and their combined effect on SBAC scores. While the effects of demographic variables in combination could provide important information, for the purposes of this study the demographic variables were only evaluated in terms of their individual interaction with CBM scores and their effect on SBAC scores.

Definition of terms

The following terms are related to this study:

Common Core State Standards (CCSS):

A set of learning goals that outline what students should be able to do or know at the end of each grade level in both English Language Arts and Mathematics (Common Core State Standards Initiative, 2018c).

Curriculum-Based Measurement (CBM):

A brief assessment measure used to track student progress. CBMs are available in multiple content areas including mathematics, reading, writing, and spelling (Lembke & Stecker, 2007).

English Language Learner (ELL):

A student whose first language, or native language, is not English and has limited English proficiency (Oregon Department of Education, 2016, p.1).

Proficiency:

Demonstrating a high degree of skill or competence in an academic area. For SBAC, a student receiving a level 3 or 4 is considered proficient (Regents of the University of California, 2018b).

Race to the Top (RTTT):

A United States Department of Education grant, introduced by the Obama administration, meant to encourage innovation and reform in K-12 education (Klein, 2014).

Smarter Balanced Assessment Consortium (SBAC):

A standardized test that is aligned to the Common Core State Standards for both English Language Arts and Mathematics, given in grades 3-8 and 11 (Regents of the University of California, 2018d).

Summary

Elementary math scores across the nation are low. This has implications for the ability of students to be career and college ready. Some agencies report that as few as 33% of students are proficient in mathematics at the elementary level (NAEP, 2017a). In reading, districts have effective methods to test for proficiency early in the year and provide students with needed interventions. In mathematics, an effective method is needed to help identify struggling students, with time to provide interventions before end of the year summative testing. This study had the potential to identify a tool for early math intervention identification in the Elk Ridge School District.

Chapter 2: Literature Review

The purpose of this literature review was to examine the current research on mathematics achievement on the Smarter Balanced Assessment Consortium, the uses of curriculum-based measurement in mathematics, the role gender plays on mathematics achievement at the elementary level, and how other demographic factors, including ethnicity, special education status, and English language learner (ELL) status, influence achievement on standardized assessments.

Mathematics Achievement and Smarter Balanced

At the time of this writing, according to the Regents of the University of California (2018c) thirteen states, including California, Connecticut, Delaware, Hawaii, Idaho, Michigan, Montana, Nevada, North Carolina, Oregon, South Dakota, Vermont, and Washington, as well as the U.S. Virgin Islands and the Bureau of Indian Education all use the Smarter Balanced assessment. The Smarter Balanced assessment test both English language arts and mathematics skills. The assessment is given to students in third through eighth grade and again in eleventh grade. With only four years of full implementation of the SBAC test, Smarter Balanced is still a relatively new assessment.

History of Smarter Balanced. As part of the American Recovery and Reinvestment Act, the Obama administration announced the Race to the Top (RTTT) initiative on July 25, 2009 (Klein, 2014). The administration offered states and districts a piece of $4.35 billion through competitive grants. A portion of the money was distributed to two consortia who were charged with creating assessments that would be a match for the common-core standards. The two groups who worked to accomplish this goal were the Partnership for the Assessment of Readiness for

College and Careers (PARCC) and the Smarter Balanced Assessment Consortium (SBAC) (Klein, 2014).

In the early 2000's each state had their own set of standards for learning that stated what students in grades 3 through 8 and high school students should know. Each state also had its own definition of proficiency. Standards, for both proficiency and learning, that varied by state made comparing scores and standardization a problem. Recognizing a need for consistency, the National Governors Association Center for Best Practices (NGA Center) and the Council for Chief State School Officers (CCSOO) launched an effort to create uniform standards in 2009 (Common Core State Standards Initiative, 2018b).

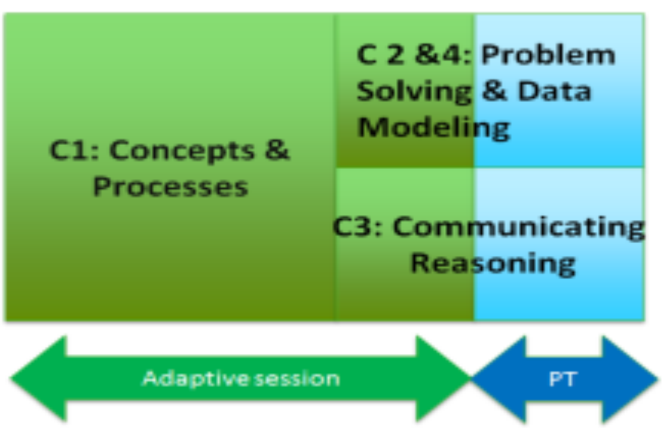
A new set of state standards was a mismatch for the testing systems in place at the time. Most states had their own testing system, much like they had their own standards. In Oregon, there was the Oregon Assessment of Knowledge and Skills (OAKS). In 2010, realizing that the current testing system was flawed, 30 states worked together to submit a grant application to create a new testing system; this was the beginning of SBAC. A federal grant of $178 million was awarded. In 2014, the federal grant ended and SBAC became a public agency housed at the University of California, Los Angeles. K-12 educators and college professors worked together to develop and test thousands of assessment items. In 2013, SBAC was pilot tested, in 2014 it was field tested, and in 2015 SBAC was put into full implementation (Regents of the University of California, 2018a). Smarter Balanced became an assessment that measures many skills and constructs and employs multiple methods for doing so.

Smarter Balanced assessment. Part of Smarter Balanced involves an adaptive component: according to the technical manual, simulations are conducted using the operational summative item pool in order to estimate test reliability. For the part of SBAC that uses a fixed

form, measurement error and reliability are calculated using psychometric properties relative to the population and number of items. The American Institutes for Research conducted a simulation study for the computer adaptive portion of SBAC. Simulation studies were also conducted by the National Center for Research on Evaluation, Standards & Student Testing. (CRESST, 2017).

Smarter Balanced measures five main constructs in third, fourth, and fifth grade. These include operations and algebraic thinking, numbers and operations in base ten, numbers and operations in fractions, measurement and data, and geometry. Smarter Balanced also measures four claims in the area of mathematics including concepts and procedures, problem solving, communicating reasoning, and modeling and data analysis (CRESST, 2017). For third through fifth grade SBAC mathematics there are two portions, the Computer Adaptive Test (CAT) and the Performance Task (PT). The following figure shows how the four claims are distributed across the two portions.

Figure 1
SBAC Four Claims Distribution



(CRESST, 2017).

In contrast to Smarter Balanced, which measures multiple claims along with grade level content standards, computation CBM measures basic fact fluency.

Curriculum-Based Measurement

In order to evaluate the success of educational programs, teaching techniques, and curriculums, measures of student achievement are needed. CBMs exist not only for math but also in the areas of oral reading fluency, early literacy, writing and secondary content. Various math CBMs gauge not only computation, this study's focus, but also application and problem solving (Tindal, 2012). Unlike SBAC, which has a short history, CBM has been in existence for over 40 years.

History of CBM. With an aim at making student achievement data central to decision-making done by teachers daily, curriculum-based measurements were created. Six years of study at the University of Minnesota were used to develop and evaluate a tool that teachers could use to make decisions about the modification of students' instruction. During the creation process there were four criteria for what would become CBM. They had to be reliable and valid, simple and efficient, easily understood, and inexpensive (Deno, 1985).

CBM was originally coined by Deno and Mirkin (1977) during their work at the *Institute for Research on Learning Disabilities* at the University of Minnesota. CBM were initially developed to measure progress of students on Individual Education Plans (IEPs) (Deno & Mirkin, 1977). After Deno and Mirkin's original publication, five years of research followed to document the technical characteristics of CBM, resulting in sixty-two research reports. As development of CBM continued, there was shift to a norm-referenced perspective where students could be compared to one another in order to identify students who had a high risk for failure-to-learn (Tindal, 2012). This study looks at computation CBM which measures basic fact fluency, a skill which is foundational to mathematics learning.

The importance of fact fluency. According to Kelley (2008), fact fluency is critical to

mathematics in the same way decoding is essential to reading. Achieving fact fluency allows students to direct their mental resources towards more complex learning tasks (McCallum, Skinner, Turner, & Saecker, 2006; Reed, Gemmink, Broens-Paffen, Kirschner, & Jolles, 2015). Research suggests that students not only need to be able to answer basic questions accurately, but it is equally important they can recall the answers rapidly (Poncy, Jaspers, Hansmann, Bui, & Matthew, 2015; Ysseldyke, Thill, Pohl, & Bolt, 2005). Fluency refers not only to accuracy, but also to speed (Poncy, McCallum, and Schmitt, 2010). According to the National Mathematics Advisory Panel (2008), it is imperative that by the end of third grade students be proficient in addition and subtraction of whole numbers, and by the end of fifth grade proficiency should extend to multiplication and division. Mastery of basic fact fluency in early elementary is related to math proficiency through middle school (Nelson, Parker, & Zaslofsky, 2016). Computational fluency is also essential for more complex mathematical tasks, including algebra (Tolar, Lederberg, & Fletcher, 2009). Mathematics is a foundational skill at the elementary level. The techniques teachers employ to teach mathematics to students at the elementary age are crucial in helping students be successful (Golafshani, 2013). Basic fact fluency is a foundation of the ability to live independently, including fluency's impact on concepts such as money and time (Patton, Cronin, Bassety, & Koppel, 1997). With fact fluency being essential to mathematical practice, screening for students lacking in fact fluency is of great importance.

CBM as screening tool for risk status. CBM can be used to determine risk status. Early identification of at-risk students in mathematics is crucial to helping students succeed on high-stakes state mandated end-of-year tests (Hughes & Dexter, 2014). There is a critical need for students in the primary grades to take valid, universal screening measures in order to be identified for interventions so they can make gains prior to the end of elementary school

(Gersten, Clarke, Jordan, Newman-Gonchar, Haymond & Wilkins, 2012). CBMs are powerful and appropriate for use in screening decisions but are not meant to be representative of overall math achievement (Christ, Scullin, Tolbize, & Jiban, 2008). Math CBMs that measure a single-skill, such as two-digit-by-two-digit addition, are a reliable measure of that construct for criterion-referenced and norm-referenced decisions (Christ, Scullin, Tolbize, & Jiban, 2008).

A study by Chafin et al. (2015) looked at the predictive validity of two types of math CBMs to determine if end-of-year results taken in second-grade would predict third-grade math performance on the Georgia mathematics state test. The correlation coefficients for the computation math CBM ranged from .710 to .237, for nine different schools (Chafin et al., 2015). Looking at studies of math CBM for both validity and reliability, Christ, Scullin, Tolbize, and Jiban (2008) warn that while most research has shown strong validity and reliability, math CBMs are designed for specific applications and specific contexts. As such, it would be unwise to use them for non-screening-type decisions just because of their high reliability (Christ, Scullin, Tolbize, & Jiban, 2008). Mathematics ability includes basic fact fluency, but also extends beyond foundational skills to include more complex skills and standards for mathematical practice.

Mathematics Ability

The Common Core State Standards Initiative (2018c) outlines eight standards for mathematical practice. These standards represent skills students in third through fifth grade should acquire while working to attain the CCSS. They include:

- Make sense of problems and persevere in solving them.
- Reason abstractly and quantitatively.
- Construct viable arguments and critique the reasoning of others.

- Model with mathematics.
- Use appropriate tools strategically.
- Attend to precision.
- Look for and make use of structure.
- Look for and express regularity in repeated reasoning.

Since SBAC tests for proficiency of the CCSS, the above skills are needed for students to be successful on SBAC. Proficiency on SBAC requires basic mathematics skills, mathematical practice skills, and a strong belief in their own mathematical competence. In a longitudinal study looking at third, fourth, and fifth graders it was found that those who who could recall facts quickly and accurately relied more frequently on fact retrieval. Those students who were more efficient and systematic at solving basic problems, had higher general mathematics achievement on tests (Vanbinst, Ceulemans, Ghesquiere, De Smedt, 2015). A study that followed students from second grade through fourth grade found that students' beliefs about their own math competence declined over time and were related to achievement. During students' third-grade year, competence beliefs began to substantially affect math grades (Weidinger, Steinmayr, & Spinath, 2018). Beliefs about one's own mathematical competence have also been shown to vary by gender.

Gender

The research indicates a disconnect between gender differences in children's perceptions of and attitudes towards their math abilities and actual gender differences in math achievement (Cvencek, Meltzoff, & Greenwald, 2011; Else-Quest, Hyde, & Linn, 2010; Herbert & Stipek, 2005; Steele, 2003). Few gender differences exist in general math skill ability at the elementary level (Leahey & Guo, 2001). Girls generally perform at the same level as their male counterparts

in math at the elementary level (Steele, 2003). While actual math ability seems to be stable for female and male students at the elementary level, perceptions of math ability vary greatly by gender. In a longitudinal study, tracking students from kindergarten or first grade through fifth grade, it was found that on average, beginning in third grade, girls rated their math abilities lower than boys did. The same study found that for actual math achievement, there was no gender difference. On both the first- and fifth-grade math achievement tests, girls outperformed boys, though not at a statistically significant level (Herbert & Stipek, 2005).

At the fourth-grade level there are countries where boys outperform girls in mathematics. There are also countries where girls outperform boys (Mullis, Martin, Foy, & Arora, 2012). Internationally, on average, on the Trends in International Mathematics and Science Study (TIMSS), there was no significant gender difference on achievement at the fourth-grade level (average scores of 490 vs. 491). Twenty-six of the 50 countries tested had no significant gender differences. Four of the remaining countries had large differences favoring girls, and 20 countries had small differences favoring boys (Mullis, Martin, Foy, & Arora, 2012). Math achievement has been found to be connected to students' beliefs about mathematical learning (House, 2006). In a meta-analysis of two international data sets, the 2003 Trends in International Mathematics and Science Study (TIMSS) and the Programme for International Student Assessment (PISA), the data revealed that on average mathematics achievement between males and females differed very little. However, overall, females held significantly less positive attitudes towards mathematics than their male counterparts (Else-Quest, Hyde, & Linn, 2010). Gender equality in school enrollment was identified as a predictor of these gender gaps (Else-Quest, Hyde, & Linn, 2010).

The math-gender stereotype that “boys are better at math” was found with elementary school children as early as first-grade on self-reporting measures. At the same grade level, boys were more likely to associate *math* with *own gender* more strongly than girls (Cvencek, Meltzoff, & Greenwald, 2011). For students in first through fifth grades taking implicit association tests and explicit self-reporting tests, it was found that students as young as second-grade had developed the concept, “math is for boys.” Overall, girls showed a weaker identification with math than their male counterparts (Cvencek, Meltzoff, & Greenwald, 2011). Gender differences have been found favoring males and their self-perception of their achievement in mathematics (Markovits & Forgasz, 2017).

Looking at intrinsic motivation and math achievement from first through fourth grades, boys showed a higher level of intrinsic motivation than girls (Garon-Carrier et al., 2016). Over time, girls’ intrinsic motivation declined significantly (Garon-Carrier et al., 2016). Significant declines in perceptions of math competencies occur between first and twelfth-grade (Fredricks & Eccles, 2002). Perception of mathematics achievement appears to decrease as students progress through grade-levels (Markovits & Forgasz, 2017). Girls’ underestimation of their own math abilities may take several years to develop (Herbert & Stipek, 2005).

It has been hypothesized that influential adults, such as parents and teachers, may contribute to girls’ underestimation of their math abilities by perpetuating the stereotype that girls are not as good at math as boys, which girls then internalize. Teachers do not rate boys’ and girls’ math abilities significantly differently at the elementary level, but parents do. Typically, parents rated the math ability of boys higher than that of girls, even though boys did not outperform girls on math assessments (Herbert & Stipek, 2005). Further, by the time students reached fifth grade, parents’ judgement of students’ math abilities was a strong predictor for

students' judgements of their own math abilities (Herbert & Stipek, 2005). Parents' beliefs are strongly associated with students' beliefs (Fredricks & Eccles, 2002). In a study of fourth and sixth grade students, boys reported that their teachers and parents believed they were good at math at a statistically significant higher rate than girls (Markovits & Forgasz, 2017).

Changes in childrens' math competencies can be predicted by gender, with boys being more likely than girls to believe they are competent in math (Fredricks & Eccles, 2002). There seem to be subtle differences in girls' perception of mathematics based on placement in single-gender or mixed-gender classrooms. First through fifth-grade girls in single-gender classrooms were found to be more likely to report that math could be used outside of school. Girls in mixed-gender classrooms were almost twice as likely to report that math is boring, over their female classmates in single-gender classrooms (Tichenor et al., 2016).

Fall, winter, and spring math CBM scores were compared for 1,626 students in grades 3 through 8, it was found that CBM scores were statistically equivalent for males and females in grades 3, 4, and 6 but females scored higher than males in grades 5, 7, and 8 (Yarbrough, Cannon, Bergman, Kidder-Ashley, McCane-Bowling, 2017). Girls' motivation in math was found to decrease between grades one and two, but remain steady from grades two to four (Garon-Carrier et al., 2016). Students' self-perceptions of their math abilities vary greatly by gender in the elementary years, although gender-differences themselves are not often found in mathematical performance in the elementary years in the United States.

Slight gender differences were seen in the Oregon results for the 2017-2018 SBAC mathematics test. 45.3% of females in third grade were considered proficient, 47.4% of males met the proficiency standards. In fourth grade 41.4% of females, and 44.5% of males were considered proficient. In fifth grade, 38.2% of females, and 40.7% of males were considered

proficient (Oregon Department of Education, 2018). Gender is just one of many demographic factors shown to impact students' achievement on standardized assessments.

Demographic Factors

In addition to gender other demographic factors such as ethnicity, special education status, English language learner (ELL) status, and socioeconomic status (SES) have been shown to impact students' standardized assessment scores.

Ethnicity. The U.S. Department of Education looked at fourth graders' mathematics scores on the National Assessment of Educational Progress across the country and found White students generally outperformed their Black, Hispanic, Pacific Islander, and American Indian/Alaskan Native counterparts. Asian students were found to have the highest scores, followed closely by fourth graders identifying as Asian/Pacific Islanders. Table 1 shows the percentage of third through fifth grade students considered proficient on SBAC mathematics in Oregon during the 2016-2017 school year broken down by ethnicity.

Table 1
SBAC Math Proficiency by Ethnicity

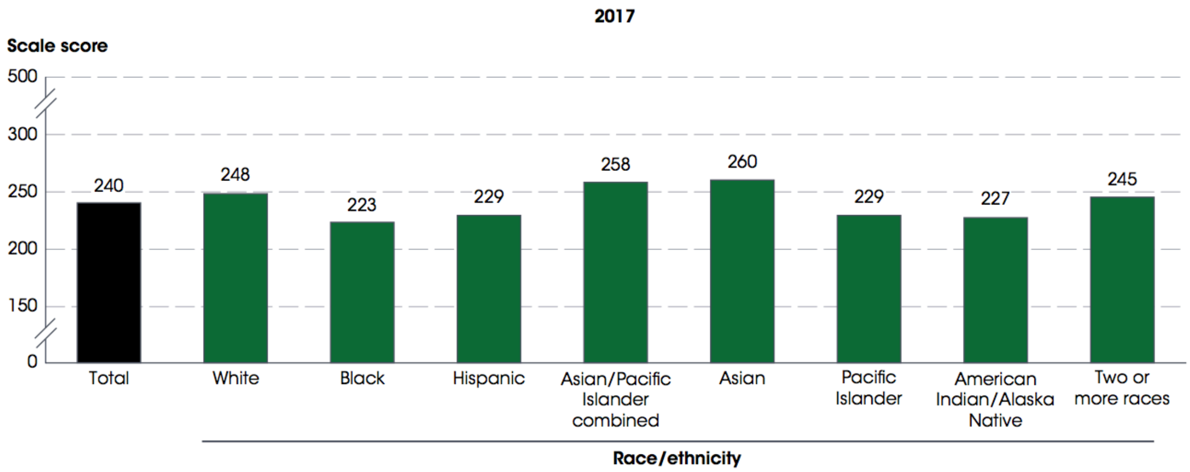
Mathematics	2016-2017	
Student Group	Number of tests	Percent meeting level 3 or 4
All students	127,071	43.6
American Indian/Alaska Native	1,627	26.6
Asian	4,898	66.7
Black/African American	2,799	20.2
Hispanic/Latino	30,947	25.8
Multi-Racial	7,999	47.5
Native Hawaiian/Pacific Islander	933	26.6
White	77,868	50.2

(Oregon Department of Education, 2017b, p.20).

As a comparison to the Oregon scores, Figure 2 presents a broader nationwide perspective. Figure 2 shows fourth-grade scores on the 2017 National Assessment of Educational Progress (NAEP) mathematics test broken down by ethnicity. On the fourth-grade NAEP mathematics test, a scale score of 249 is considered proficient. A scale score of 214 is considered basic, where students are able to demonstrate some understanding in the five NAEP content areas (number properties and operations, measurement, geometry, data analysis and probability, and algebra). An advanced score is 282 or above (NAEP, 2017b).

Figure 2

Fourth Grade 2017 performance on NAEP mathematics by race/ethnicity.



(McFarland et al., 2018, p. 111)

While at first glance, the difference between groups may not seem large, the discrepancies in scores represent large differences in mathematics ability. For instance, a score of 223 (The average score of the student population identifying as Black) is close to a "basic" score meaning that a fourth grade student, "…should be able to estimate and use basic facts to perform simple computations with whole numbers, show some understanding of fractions and decimals, and solve some simple real-world problems in all NAEP content areas" (NAEP, 2017b, p.1) In addition, "Their written responses will often be minimal and presented without supporting information" (NAEP, 2017b, p.1) In contrast, with a score of 258 (The average score of the student population identifying as Asian/Pacific Islander) fourth grade students "…should be able to use whole numbers to estimate, compute, and determine whether results are reasonable. They should have a conceptual understanding of fractions and decimals; be able to solve real-world problems in all NAEP content areas" (NAEP, 2017b, p.1) Students receiving a score of 258 should also be able to "…employ problem-solving strategies such as identifying and using appropriate information. Their written solutions should be organized and presented both with supporting information and explanations of how they were achieved" (NAEP, 2017b, p.1). While

these two scores are only 35 points apart, one is representative of a student who has a strong grasp on mathematics concepts needed to be successful at the fourth grade level. The other indicates that a student only has emerging skills, and still needs support to be successful at the fourth-grade level.

Oregon's achievement broken down by ethnicity is a close reflection to the nation as a whole. Both in Oregon, and nationwide, Asian students have the highest percentage of their total population meeting proficiency standards. This is followed by White students and students who identify as two or more races. In both data sets Hispanic and Black students had a lower percentage of their total population meeting proficiency standards than their Asian or White counterparts. Like ethnicity, special education is another demographic factor shown to impact assessment results.

Special education. According to the National Center for Education Statistics (2018) 13.2% of students in public education are receiving special education services. In Oregon, during the 2016-2017 school year, 13.5% of students received special education services (ODE, 2017b). The Oregon Department of Education (2017a) reports that of students with disabilities receiving accommodations, only 10% of third graders, 7.6% of fourth graders, and 5.9% of fifth graders were meeting proficiency standards in math. Table 2 shows the percentage of third- through fifth-grade students considered proficient on SBAC mathematics in Oregon during the 2016-2017 school year for all students compared to those with disabilities.

Table 2
SBAC Math Proficiency for All Students and Those with Disabilities

Mathematics	2016-2017	
Student Group	Number of tests	Percent meeting level 3 or 4
All students	127,071	43.6
Students with Disabilities	18,911	21.1

(Oregon Department of Education, 2017b, p.20).

Nationwide on the NAEP assessment of fourth-grade students, those with disabilities had an average score of 214 (just meeting the qualification for basic understanding). Students without disabilities had an average score of 243 (missing the proficiency score by 6 points) (The Nations Report Card, 2017). Oregon's scores mirror the nationwide trend that students with disabilities tend to score lower on large-scale assessments. While there are multiple ways students might qualify for an individual education plan (IEP), intellectual disability is one qualification. If the percentage of students with disabilities meeting proficiency matched the general population, it would raise a concern about over-qualification for SPED. It makes sense for students with certain classifications of disabilities to score lower, on average, than the general education population. Special education is an interesting demographic to consider when looking at assessment scores, another demographic that yields interesting results is English language learner status.

English language learners. According to the Oregon Department of Education (2018) only 13.9% of third-graders, 9.0% of fourth-graders, and 6.0% of fifth-graders in Oregon who were considered English Learners (EL) were considered proficient (level 3 or 4) on the SBAC mathematics test during the 2017-2018 school year. Table 3 shows the percentage of third through fifth grade students considered proficient on SBAC mathematics in Oregon during the

2016-2017 school year for those qualified as English Learners and those whose native language is English.

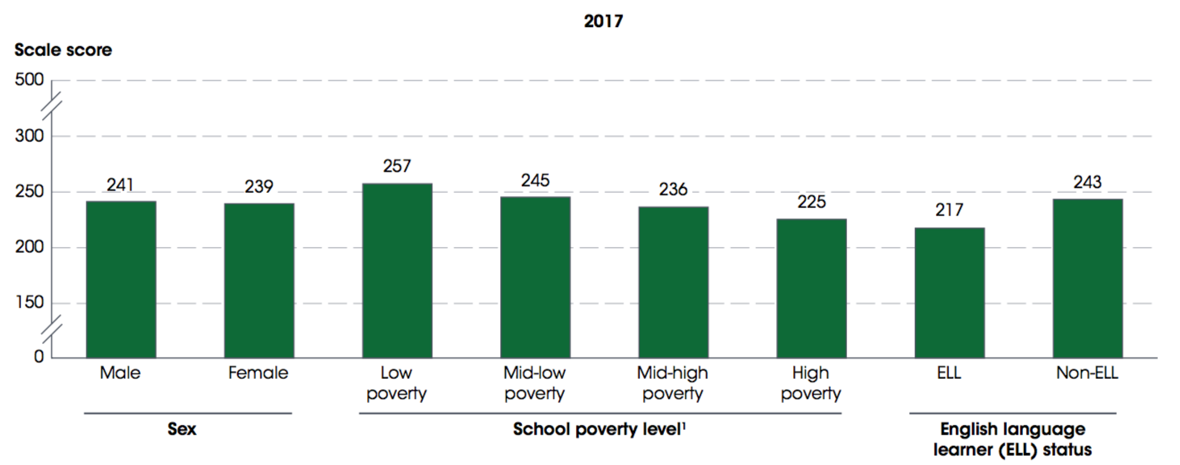
Table 3
SBAC Math Proficiency for English Leaners and Native English Speakers

Mathematics	2016-2017	
Student Group	Number of tests	Percent meeting level 3 or 4
All students	127,071	43.6
English Learners	22,175	19.8

(Oregon Department of Education, 2017b, p.20).

As a comparison to Oregon results, Figure 3 shows a breakdown of ELLs vs. Non-ELLs on the 2017 NAEP mathematics test for fourth-graders given nationwide. Figure 3 also shows a breakdown of NAEP results by sex and school poverty level. Keep in mind that a score of 214 is "basic," a score of 249 is "proficient," and a score of 282 is "advanced" on the NAEP mathematics assessment (NAEP, 2017b).

Figure 3
Fourth Grade 2017 performance on NAEP mathematics by sex, poverty level, and ELL status.



(McFarland et al., 2018, p. 111)

As was the case in Figure 2, the scores recorded in Figure 3 represent a large range in math ability, even if the scores may initially appear close together. A score of 217, for instance, indicates that the student struggles to solve problems with more than one step and often cannot explain or defend their work. A student scoring a 257 is able to solve multi-step problems and explain their work.

In both the Oregon data and the national NAEP data it can be seen that English language learners are lagging behind their native English-speaking counterparts. These results are not unexpected. Mathematics assessments are fraught with mathematics specific vocabulary. English learners are contending with taking a test with directions and problems written in a second language, on top of which they are asked to perform mathematical operations.

Socioeconomic status. According to the Oregon Department of Education (2018) only 34.5% of third-graders, 30.7% of fourth-graders, and 27.0% of fifth-graders in Oregon who were economically disadvantaged were considered proficient (level 3 or 4) on the SBAC mathematics test during the 2017-2018 school year. A study in Peru found that students' SES status at the age of one was highly correlated to their math achievement in fourth-grade (Cueto, Guerrero, Leon, Zapata, & Freire, 2014). Low SES was also correlated with fewer opportunities to learn which may account for the lower levels of math achievement (Cueto, Guerrero, Leon, Zapata, & Freire, 2014).

In his meta-analysis of 74 studies, looking at the relationship between SES and academic achievement, Sirin (2005) found that family SES is a strong predictor of academic performance. The study also found that the relationship between SES and academic performance begins in primary school and increases across levels of schooling (Sirin, 2005). SES was found to be a weaker predictor of academic achievement for minority students than for White students (Sirin,

2005). Table 4 shows a breakdown for SBAC math scores in the state of Oregon based on economically disadvantaged status.

Table 4
SBAC Math Proficiency Broken Down by Economically Disadvantaged Status

Mathematics	2016-2017	
Student Group	Number of tests	Percent meeting level 3 or 4
All students	127,071	43.6
Economically Disadvantaged	78,479	31.6

(Oregon Department of Education, 2017b, p.20).

Students in Oregon who are considered economically disadvantaged are less likely to be proficient in mathematics. The same is true nationwide, where it is found that as poverty scores increase academic scores decrease. Payne (2005) says, "One of the reasons it is getting more and more difficult to conduct school as we have in the past is that the students who bring the middle-class culture with them are decreasing in numbers, and the students who bring the poverty culture with them are increasing in number" (p. 61). This trend calls for a change in teaching practice, and may be one of the reasons for the low scores of students with low SES. With low scores, educators look to identification of needs and targeted intervention to help struggling learners.

Summary

This chapter investigated studies looking at both SBAC and math CBM, what general math abilities students in third through fifth grade should be able to demonstrate, the role of students' beliefs about their own mathematical abilities, as well as differences in standardized testing based on demographic factors. CBM can be a powerful predictor of students who are at-risk for failure to learn basic skills. Gender differences exist in students' perceptions of their

mathematical abilities. Demographic factors including SES, SPED status, ELL status, and ethnicity all have an impact on standardized test scores.

Chapter 3: Methodology

This chapter outlines the research design of this study, including information on the sampling plan, the instruments that were used, the data collection process, data analysis, and ethical considerations of the study.

Research Questions

This study explored three research questions.

1. To what extent do mathematics curriculum-based measurements taken in the fall predict mathematics SBAC scores taken at the end of year for students in third, fourth, and fifth grade?
2. To what extent does gender interact with mathematics CBM scores to predict mathematics SBAC scores?
3. To what extent do mathematics curriculum-based measurements taken in the fall, together with demographic factors for ethnicity, special education status, and English language learner (ELL) status predict mathematics SBAC scores taken at the end of year in the third, fourth, and fifth grades?

Design

This study was a quantitative *ex post facto* longitudinal study using secondary data collected during the 2017-2018 school year. It was longitudinal because math CBM scores were collected in the fall of 2017 and math SBAC scores were collected in the spring of 2018. This study used census sampling; and included the entire population of third-, fourth-, and fifth-grade students during the 2017-2018 school year. The data was analyzed using hierarchical multiple regression. In this analysis, the data was entered into the model in steps allowing for control of the effects of covariates as well as taking into account possible causal effects of independent

variables when predicting a dependent variable (Laerd, 2018a). Hierarchical multiple regression allowed for determining "how much extra variation in the dependent variable can be explained by the addition of one or more independent variables" (Laerd, 2018a, p. 1).

This study examined the predictive relationship between two instruments: CBM and SBAC. CBMs are timed assessments that measure specific mathematical operations. In third grade, CBM measures multiplication with products between 0 and 144. In fourth grade, they measure multiplication facts with products between 0 and 144 on one assessment, and division facts with quotients from 0 to 12 on a second assessment. In fifth grade, CBM assesses students' multiplication fact knowledge with products between 0 and 144, as well as division facts with quotients from 0 to 12 on one combined assessment. "Measures can either be scored by counting the number of correct problems, number of correct digits in the answer, or, in the case of concepts and applications problems, number of blanks correctly filled-in" (Lembke & Stecker, 2007, p. 13). In the Elk Ridge School District, computation math CBMs were scored by counting the number of correct problems.

SBAC measures five major constructs: operations and algebraic thinking, numbers and operations in base ten, fractions, geometry, and measurement and data. According to the SBAC technical report, reliability coefficients for SBAC math in third through fifth grade ranged from .90 to .95. Marginal reliability differs based on ethnic group (CRESST, 2017). Table 5 shows reliability coefficients for different ethnic groups for grades three, four, and five on the SBAC mathematics measure.

Table 5

Reliability Coefficients of SBAC Math for Ethnicity Groups.

Grade	Group	N	Marginal Reliability
3	All	728,663	0.94
	American Indian/Alaska Native	11,467	0.92
	Asian	9,981	0.95
	Black/African American	8,702	0.93
	Hispanic/Latino	310,981	0.93
	White	148,585	0.94
4	All	736,908	0.94
	American Indian/Alaska Native	11,285	0.92
	Asian	9,822	0.95
	Black/African American	8,493	0.93
	Hispanic/Latino	316,631	0.93
	White	145,010	0.94
5	All	723,478	0.93
	American Indian/Alaska Native	11,254	0.90
	Asian	10,469	0.95
	Black/African American	8,212	0.91
	Hispanic/Latino	305,746	0.90
	White	143,077	0.94

(CRESST, 2017).

For those who were considered economically disadvantaged in third and fourth grade marginal reliability was 0.93, and for those in fifth grade, it was 0.91 (CRESST, 2017, p.68). The technical manual cautions that while it has studied the association between SBAC and tests that contain similar constructs, it has not yet been able to associate its results with another data set with a common pool of test items (CRESST, 2017, p.32). SBAC is still relatively new, and much more testing needs to be conducted on its validity, reliability, and bias.

For SBAC assessments, scores range from 2000 to 3000. These scores are then translated into achievement levels. SBAC has four achievement levels:

1. Has not met the achievement standard (minimal command of knowledge, skills, and processes).
2. Nearly met the achievement standard (partial command of knowledge, skills and processes).
3. Has met the achievement standard (sufficient command of knowledge, skills, and processes).

4. Exceeded the achievement standard (deep command of knowledge, skills, and processes).

(Oregon Department of Education, 2013).

For this study, data analysis used participants' scores and not achievement levels. While knowing a students' SBAC level provides some information about their current skills and abilities, there is a large range of scores within each level. Using students exact score, instead of their achievement level, allowed for more specific results. Table 6 shows a breakdown of achievement levels based on scores for third, fourth, and fifth grade.

Table 6
SBAC Mathematics Achievement Levels

Grade	Level 1	Level 2	Level 3	Level 4
3	<2381	2381–2435	2436–2500	>2500
4	<2411	2411–2484	2485–2548	>2548
5	<2455	2455–2527	2528–2578	>2578

(Regents of the University of California, 2018b).

Data analysis was completed in SPSS. Table 7 shows the variables that were used in the data analysis.

Table 7

Dependent and Independent Variables

Dependent or Independent	Variable	Operationalized as…
Dependent Variable	SBAC math score	Score between 2000-3000
Independent Variable	CBM score	Score between 0-84
Independent Variable	Gender	Male or Female
Independent Variable	Classification for SPED	Yes or No
Independent Variable	ELL Status	Yes or No
Independent Variable	Ethnicity	Hispanic/Latino, White, or Other (American Indian/Alaska Native, Asian, Black/African American, Native Hawaiian/Pacific Islander, and Multi-Racial)[a]

Note. [a]These categories were chosen because approximately 85% of the students in this sample identify as White or Hispanic/Latino. The remaining 15% of students identify as American Indian/Alaska Native, Asian, Black/African American, Native Hawaiian/Pacific Islander, or Multi-Racial with no more than 6% of the population in any one category (Oregon Department of Education, 2017a).

Originally socioeconomic status (SES) qualification was supposed to act as an additional independent variable. SES data was not able to be obtained, and therefore was not included as a variable in this study.

Setting and Participants

The sample for this study was comprised of students enrolled in third, fourth, or fifth grade in the Elk Ridge School District during the 2017-2018 school year. To be included in this study, students had to meet the above enrollment requirement. In addition, participants had to meet the inclusion criteria of having a record exist for the fall 2017 CBM measure. Finally, participants had to have a record for their SBAC math score, collected during the spring of 2018. The sample size for this study was 2,741.

The Elk Ridge School District was selected as the sample for this study for several reasons. First, this was a convenience sample. I was able to gain access to data needed for the study. The second reason is that the school district has questioned how best to use CBM data, and this study had the potential to be useful to the district in future decision making. Finally, the Elk Ridge School District had a unique population. It is one of the top ten largest school districts in the state of Oregon, serving almost 13,000 students. According to the 2016-2017 Oregon Report Card, 42% of students in grades K-3 and 43% of students in grades 4-5 were economically disadvantaged. For students in grades K-3, 8% were students with disabilities: this number increases to 12% for those who were in grades 4 and 5 (Oregon Department of Education, 2017a). In Oregon, 10.5% of the public-school population were considered to be English Language Learners (ELL): in the Elk Ridge School District, the percent of ELLs was 20% in grades K-3, and 26% in grades 4-5 (Oregon Department of Education, 2017b). Due to the unique population of the district, it was an important one to study, potentially offering a way to identify those in vulnerable populations who need additional interventions. The unique population also meant the study had low external validity and limited generalizability to other populations.

Analysis

Data analysis occurred in SPSS using hierarchical multiple regression. This approach was selected because of the ability to enter variables into the model in steps.

> What makes a hierarchical approach different from one of the step procedures is that the researchers rationally determine which variables they would like to use as covariates at each step in the analysis. Particular attention is paid to the amount of predictability (explanation) that is gained-assessed by the change in R2- with each new block of

variables added to the previous model in forming a new (expanded) model (Meyers, Gamst, & Guarino, 2017 p. 206).

There are eight assumptions of a hierarchical multiple regression. The first two relate to the study design (a) there is a continuous dependent variable and (b) there are two or more independent variables that are either continuous or categorical. In this study the continuous dependent variable was math SBAC scores reported at an interval level (scores between 2,000 and 3,000). There were also more than two independent variables including four nominal variables (gender, ethnicity, ELL, and SPED) as well as one continuous independent variable, CBM scores reported on a ratio scale (scores between 0 and 84). The last six assumptions of a hierarchical multiple regression can be tested using SPSS (Laerd, 2018b). Table 8 shows the assumptions of a hierarchical regression and the tests that were conducted in SPSS.

Table 8
Hierarchical regression assumptions and tests.

Assumption	SPSS test
Independence of observations	Durbin-Watson statistic
There needs to be a linear relationship between (a) the dependent variable and each of your independent variables, and (b) the dependent variable and the independent variables collectively	Scatterplot/Partial regression plot
Data needs to show homoscedasticity of residuals (equal error variances)	Plotting the studentized residuals against the unstandardized predicted values/ weighted least squares (WLS) regression
Data must not show multicollinearity	Correlation coefficients and Tolerance/VIF values
There should be no significant outliers, high leverage points or highly influential points	Casewise diagnostics and studentized deleted residuals/Cook's Distance
You need to check that the residuals (errors) are approximately normally distributed	Histogram with superimposed normal curve and a P-P Plot

(Laerd, 2018b).

Analyses for this study were done using SPSS. The covariates were entered into the regression equation first; these include ethnicity, English language learner status, and special education status. Gender was entered into the model next. Finally, CBM scores were entered into the model. This allowed for CBM scores to be assessed after controlling for covariates (Laerd, 2018c).

Model 1: $Y = a + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3$

Y: SBAC mathematics score

a: intercept

β_1: slope coefficient for ethnicity

X_1: ethnicity

β_2: slope coefficient for ELL status

X_2: ELL status

β_3: slope coefficient for SPED status

X_3: SPED status

Model 2: $Y = a + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4$

Y: SBAC mathematics score

a: intercept

β_1: slope coefficient for ethnicity

X_1: ethnicity

β_2: slope coefficient for ELL status

X_2: ELL status

β_3: slope coefficient for SPED status

X_3: SPED status

β_4: slope coefficient for gender

X_4: gender

$$Model\ 3{:}\ Y = a + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5$$

Y: SBAC mathematics score

a: intercept

β_1: slope coefficient for ethnicity

X_1: ethnicity

β_2: slope coefficient for ELL status

X_2: ELL status

β_3: slope coefficient for SPED status

X_3: SPED status

β_4: slope coefficient for gender

X_4: gender

β_5: slope coefficient for math CSB score

X_5: math CBM score

Hypotheses

1. To what extent do mathematics CBM measurements taken in the fall predict mathematics SBAC scores taken at end-of-year for students in third, fourth, and fifth grade?

   H_{01}: There will be no significant prediction of math SBAC scores in third, fourth, or fifth grade by fall math CBM scores.

   H_1: There will be significant prediction of math SBAC scores in third, fourth, or fifth grade by fall math CBM scores.

2. To what extent does gender interact with mathematics CBM scores to predict mathematics SBAC scores?

   H_{02}: There will be no significant prediction of mathematics SBAC scores by gender.

   H_2: There will be significant prediction of mathematics SBAC scores by gender.

3. To what extent do mathematics curriculum-based measurements taken in the fall, together with demographic factors for ethnicity, special education status, and English language learner (ELL) status predict mathematics SBAC scores taken at end-of-year in the third, fourth, and fifth grades?

   H_{O3}: There will be no significant predication of mathematics SBAC scores by ethnicity, special education status, or English language learner status.

   H_3: There will be significant predication of mathematics SBAC scores by ethnicity, special education status, or English language learner status.

Significance

This study has practical significance for the district in which data exists. Given each individual grade level, if CBMs are predictive of SBAC scores, then CBMs should be used to determine who needs additional intervention time. Given each individual grade level, if CBMs are not predictive of SBAC scores, then math CBMs should be eliminated to relieve testing load. If, given each individual grade level, gender differences do exist, instructional practices to eliminate a gender gap in mathematics should be considered by the district.

Currently, it is up to individual educators to choose how to use CBM results in their classrooms, if at all. Few colleagues use them, particularly in light of the fact that the current curriculum provides other ways to measure math fact fluency. However, some teachers choose to use CBM results to determine how much additional fact fluency practice to incorporate outside

of the time designated in the schedule for mathematics teaching. Many educators have recognized that fact fluency is foundational, influencing all other concepts taught throughout the year. Due to the recognized importance, fact fluency practice is often incorporated into the teaching day.

Ethics

I am a student at George Fox University, and conducted this study as a requirement for the completion of a doctoral degree. I am also a fourth-grade teacher. I am personally interested in the findings of this study. The results of this study will influence my own use of CBMs in my classroom. As a teacher I administered both fall CBM and spring math SBAC. Due to the fact that I am interested in the results of this study, it was important that the data I received from the district not contain names or student identification numbers.

I received IRB approval prior to submitting a formal request to the school district. In my request to the school district, I asked that all data be de-identified of student names and student identification numbers. Data was stored on a secure USB drive, and kept in a locked drawer in my office. The data was used on a password-protected computer, and will be destroyed five years after the completion of the study.

Role of the Researcher

I came to this research not only as a researcher but also as a practitioner. I am passionate about helping my students succeed, and the lens through which I see the importance of this work is sure to impact the work itself. I work with students each year whose math abilities are well below grade level standards. One of my jobs as an educator is to build a case for getting my lowest performing students extra support. I do this through classroom data, formal and informal, as well as assessments. The findings of this study had the potential to influence the ways in

which I build that case, potentially allowing me to include CBM scores as one small piece of evidence among others to support a request for extra help.

Because the findings of this study had the potential to impact the help I can offer to my own students, my resolve to conduct unbiased work was critical. I took precautions to prevent my own bias from influencing this study to the best of my ability, including having my committee review my work and ensuring data was free from student names and identification numbers. I recognized and acknowledged the impact my role as active practitioner had on my work.

Summary

This study utilized already collected data from one school district in Oregon. Census sampling was used for students who were in third, fourth, and fifth grade during the 2017-2018 school year. A hierarchical multiple regression analysis was used to analyze the three research questions informing this study. Data analysis was conducted using SPSS. It was important to be aware of personal biases during the duration of this study. The following chapter presents results from the data analysis.

Chapter 4: Results

The purpose of this study was to examine the predictive validity of third through fifth grade mathematics CBMs on mathematics SBAC scores for the 2017-2018 school year in the Elk Ridge School District. This study used a hierarchical regression model to examine the relationship between CBMs and SBAC when controlling for the covariates of gender, ethnicity, English Language Learner (ELL) status, and Special Education (SPED) status. Third-grade CBM was a single assessment that measured multiplication skills, while fifth-grade CBM was a single assessment that measured multiplication and division skills combined. Fourth-grade CBM was given as two assessments, the first measured multiplication skills and the second division skills. For this reason, each fourth grader was recorded twice in the data set; once with their multiplication score, and once with their division score. Due to the nature of the data, it was necessary to run two separate hierarchical multiple regressions. The first set of data, hereafter referred to as data set A, included all third and fifth grade data, along with fourth grade data for division. The second set of data, hereafter referred to as data set B, included all third and fifth grade data, along with fourth grade data for multiplication. The results from data set A and data set B have many similarities; considering that third and fifth grade data is included in both data sets this is not surprising. Results, however, do vary between data set A and data set B; both data sets are presented throughout this chapter.

Table 9
Differences in Data Sets

CBM	Data Set A	Data Set B
Third Grade: Multiplication	X	X
Fourth Grade: Multiplication		X
Fourth Grade: Division	X	
Fifth Grade: Multiplication/ Division Combined	X	X

Sample Demographics

The population examined included students who were in third, fourth, and fifth grade in the Elk Ridge School District during the 2017-2018 school year. The sample had 2,741 participants. Table 10 presents sample demographics for data analysis A, which included third-grade CBM, fifth-grade CBM, and the fourth-grade division CBM. Table 11 presents sample demographics for data set B, which included third-grade CBM, fifth-grade CBM, and the fourth-grade multiplication CBM. Both data sets show that 57.1% of the participants identified as White, 28.4% identified as Hispanic, and 14.5% identified as an ethnicity other than White or Hispanic, including Native Hawaiian/Other Pacific Islander, Two or More, Asian, Black/African American, or American Indian/Alaskan Native. This sample had a lower percentage of White participants than the state percentage of 63%. The sample also showed a higher percentage of Hispanic participants than the state percentage of 22.6%. The percentage of students identifying as Other (14.5%) was a close match for the state percentage of 14.4%. In both data sets, 8.9% of the participants qualified for Special Education, less than the district percentage of 10.3% or the state percentage of 13.5%. In both data sets the percentage of students qualifying for English Language Learner status was 9.4%; well below the district percentage of 23.75%, but close to the

state percentage of 10.5%. See Table 10 and 11 below for further sample demographic information.

Table 10
Sample Demographics Data Set A

Demographic characteristic	Count of sample (Sample %)	District %	State %
Gender			
Male	1410 (51.5)		
Female	1326 (48.5)		
Ethnicity			
White	1561 (57.1)	58	63
Hispanic	777 (28.4)	26	22.6
Other	397 (14.5)	16	14.4
Special Education Status			
SpEd	243 (8.9)	10.3	13.5
Not SpEd	2493 (91.1)	89.7	86.5
ELL Status			
ELL	258 (9.4)	23.75	10.5
Not ELL	2478 (90.6)	76.25	89.5
Grade Level			
Third	893 (32.6)		
Fourth	938 (34.3)		
Fifth	905 (33.1)		

Note. SpEd = Special Education. ELL = English Language Learner.

Table 11
Sample Demographics Data Set B

Demographic characteristic	Count of sample (Sample %)	District %	State %
Gender			
Male	1415 (51.6)		
Female	1326 (48.4)		
Ethnicity			
White	1564 (57.1)	58	63
Hispanic	779 (28.4)	26	22.6
Other	397 (14.5)	16	14.4
Special Education Status			
SpEd	244 (8.9)	10.3	13.5
Not SpEd	2497 (91.1)	89.7	86.5
ELL Status			
ELL	258 (9.4)	23.75	10.5
Not ELL	2483 (90.6)	76.25	89.5
Grade Level			
Third	893 (32.6)		
Fourth	943 (34.4)		
Fifth	905 (33.0)		

Note. SpEd = Special Education. ELL = English Language Learner.

Descriptive Statistics

For SBAC there are four score levels. Earning a level-one score means the student has not met the achievement standard. Earning a level-two score means the student has nearly met the achievement standard. A level-three score means the student has met the achievement standard. Earning a level-four score means the student has exceeded the achievement standard. For this study's sample, the mean SBAC score in data set A was 2488.73 (M = 2488.73, SD = 97.014). For data set B the mean SBAC score was 2488.75 (M = 2488.75, SD = 97.014). In third grade, a score of 2488 would fall in the level-three score category (2436-2500); meets standard. In fourth grade, a score of 2488 would fall just inside the level-three score category (2485-2548); meets standard. In fifth grade, a score of 2488 would fall in the level-two score category (2455-2527); approaches standard. The mean score for both data set A and data set B show that, in

general, most scores fell between a level-two and level-three category, indicating that most students were either meeting or nearly meeting the standard.

The descriptive statistics for both data sets are almost identical. The largest discrepancy between the two data sets occurs in the mean of CBM test scores. For data set A, the mean of CBM test scores was 10.27 (± 9.35); for the second data set, the mean was 12.35 (± 9.96). The discrepancy makes sense considering the fact that the first data set includes fourth-grade division scores and the second data set includes fourth-grade multiplication scores. It would be expected that a student beginning their fourth-grade year would have a stronger ability to complete multiplication facts over division facts because of the amount of time spent on multiplication in third grade, which is in line with Common Core State Standards. Table 12 offers descriptive statistics for data set A, Table 13 offers descriptive statistics for data set B.

Table 12
Descriptive Statistics for Data Set A

	M	*SD*	*N*
SBAC Score	2488.73	97.01	2735
CBM Test Score	10.27	9.36	2735

Table 13
Descriptive Statistics for Data Set B

	M	*SD*	*N*
SBAC Score	2488.75	97.01	2740
CBM Test Score	12.35	9.97	2740

Assumptions

There are eight assumptions of a hierarchical multiple regression. The first two are considered design assumptions and both were easily met. Assumption number one requires a continuous dependent variable. In this study, the continuous dependent variable was math SBAC

scores reported at an interval level (scores between 2,000 and 3,000). The second assumption is that there are two or more independent variables that are either continuous or categorical. This study used five independent variables including four nominal variables (gender, ethnicity, ELL status, and SPED status), as well as one continuous independent variable-CBM scores-reported on a ratio scale (scores between 0 and 84). The other six assumptions are statistical assumptions and as such are tested only after the data is collected. They are: (a) independence of observations, (b) linear relationship between the dependent variable and each independent variable as well as the dependent variable and the independent variables collectively, (c) homoscedasticity of residuals, (d) no multicollinearity, (e) no significant outliers, and (f) residuals approximately normally distributed. All six statistical assumptions were met and the findings are reported below.

Independence of observations. The Durbin-Watson statistic was used to test for independence of observations. In both regressions there was independence of residuals, as assessed by the Durbin-Watson (D-W) statistics of 1.683 and 1.687 respectively (see Table 14 and Table 15). An acceptable D-W statistic lies between 1.5 and 2.5 (LAERD, 2015).

Linear relationship between dependent and independent variables. The linear relationship between the dependent variable (math SBAC scores) and the continuous independent variable (CBM scores) was examined by using partial regression plots (Figure 4 and Figure 5 in Appendix F). Linearity is assumed as long as there is no overt curvilinear or non-monotonic pattern. A linear relationship could be assumed since the plots show no such curvilinear or non-monotonic relationship between the CBM and SBAC scores. The other independent variables (ELL status, SPED status, gender, and ethnicity) are categorical and therefore do not need to be assessed for this assumption to be met.

Homoscedasticity of residuals. To test that the variance was equal for all values of the predicted dependent variable the studentized residuals were plotted against the unstandardized predicted values (see Figure 6 and Figure 7 in Appendix F). Homoscedasticity was visually inspected using these plots, and is typically assumed in the absence of any clear visual funnels. "There was homoscedasticity, as assessed by visual inspection of a plot of studentized residuals versus unstandardized predicted values" (LAERD, 2018d, p. 1).

No multicollinearity. Correlation coefficients and Tolerance/VIF values were used to assess for collinearity. To meet the assumption that independent variables do not highly correlate with other variables, Tolerance and VIF values can be consulted. When the Tolerance values are greater than 0.1 and VIF values are less than 10, the conditions for no multicollinearity are met. These values, that show Tolerance values greater than 0.1 and VIF values less than 10, are presented in Table 20 and Table 21 in Appendix F.

No significant outliers. Casewise diagnostics were used to detect for outliers. For data set A, 17 outliers were detected, or 0.62 percent. For data set B, 16 outliers were detected, or 0.58 percent. For any data set that follows a normal distribution it would be expected that about one percent of the data would lie outside plus or minus three standard deviations.

The outliers produced some interesting patterns. For both data sets, only two of the outliers, for high and low scores, were female (12.5% and 11.7% of the outliers respectively). In both data sets, one female had a low outlying score and one a high outlying score. There was only one outlying score that belonged to a participant who qualified for ELL status. This participant showed up in both data sets (a third grader). Their SBAC score was an outlier for being low.

There was also an interesting pattern regarding outliers for participants who qualified for SPED. In data set A, six of 17, or 35 percent of the outliers, were from participants who qualified for SPED. Of those six participants, two were outliers due to low scores, while four were outliers due to high scores. In data set B, five of 16, or 31 percent of the outliers, were participants who qualified for SPED. Of those five participants, three were outliers with low scores, and two were outliers for high scores. It might be expected that students with a SPED qualification would not be outliers due to high scores. This was not the case in these two data sets. See Table 22 and Table 23 in Appendix G for more information on casewise diagnostics.

Residuals are approximately normally distributed. To check for normal distribution of residuals, both a histogram of the residuals and a P-P plot were used. The histograms for both sets of data show that the residuals were approximately normally distributed (Figure 8 and Figure 9 in Appendix F). To confirm these findings, P-P plots (Figure 10 and Figure 11 in Appendix F) were used. For both sets of data, the P-P plots showed that the residuals were approximately normally distributed.

See Appendix F for additional details on the testing of assumptions.

Analysis

Both analyses included three regression models. In model 1, the variables for ethnicity, SPED status, and ELL status were entered. In model 2, gender was added to the previous model. In model 3, CBM scores were added to the previous model. For the model summary for data set A, see Table 14 and for the model summary for data set B, see Table 15.

Table 14
Model Summary Data Set A

					Change Statistics					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change	Durbin-Watson
1	.509[a]	0.259	0.258	83.558	0.259	238.868	4	2730	0.000	
2	.515[b]	0.265	0.264	83.235	0.006	22.211	1	2729	0.000	
3	.674[c]	0.455	0.453	71.726	0.189	947.039	1	2728	0.000	1.683

Table 15
Model Summary Data Set B

					Change Statistics					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change	Durbin-Watson
1	.509[a]	0.259	0.258	83.547	0.259	239.377	4	2735	0.000	
2	.515[b]	0.265	0.264	83.223	0.006	22.299	1	2734	0.000	
3	.672[c]	0.451	0.450	71.939	0.186	925.964	1	2733	0.000	1.687

Research Questions

This study looked at three research questions.

1. *To what extent do mathematics curriculum-based measurements taken in the fall predict mathematics SBAC scores taken at end-of-year for students in third, fourth, and fifth grade?*

Hierarchical multiple regression was run with CBM scores as a predictor of math SBAC scores after controlling for covariates of ethnicity, ELL status, SPED status, and gender. The analysis showed that the addition of CBM scores to the prediction of SBAC scores (Model 3) for data set A led to a statistically significant increase in R^2 of .189, $F(1, 2728) = 947.039$, $p < .001$ (LAERD, 2015). Thus, the addition of the two models contributed a total of 18% of explained

variance that all independent variables contributed to explaining the dependent variable. For data set B, the addition of CBM scores to the prediction of SBAC scores (Model 3) led to a statistically significant increase in R^2 of .186, F(1, 2733) = 925.964, p < .001 (LAERD, 2015). In other words, the addition of the two models contributed a total of 18% of explained variance that all independent variables contributed to explaining the dependent variable.

ANOVA tests show that the relationship between CBM scores and SBAC scores was statistically significant. The full model of ethnicity, SPED status, ELL status, gender, and CBM scores to predict SBAC scores (Model 3) was statistically significant, $R^2 = .455$, $F(6, 2734) = 378.941$, $p < .001$, adjusted $R^2 = .453$ for data set A (LAERD, 2015)(see Table 16). In other words, the combined predictors in this linear combination were able to explain about 45% of the variance of SBAC scores. The full model of ethnicity, SPED status, ELL status, gender, and CBM scores to predict SBAC scores (Model 3) was statistically significant, $R^2 = .451$, $F(6, 2739) = 374.593$, $p < .001$, adjusted $R^2 = .450$ for data set B (LAERD, 2015) (see Table 17). This means that the combined predictors of CBM score, gender, ethnicity, SPED status, and ELL status were able to explain about 45% of the variance of SBAC scores. According to Meyers, Gamst, and Guarino (2017), "…R^2 values, .10, .25, and .40 might be considered to be small, medium, and large strengths of effect, respectively" (p. 175). That authors do caution that context also plays a role in determining magnitude of effect (Meyers, Gamst, & Guarino, 2017). Adjusted R^2 for data set A was .453 and for data set B was .450. "This adjusted R^2 provides an estimate of what the R^2 might have been had it not been inflated by the number of predictors we have included in the model relative to our sample size" (Meyers, Gamst, & Guarino, 2017, p. 177). In other words, for the full model, all of the predictors combined were able to explain about 45% of the variance in SBAC scores in both data set A and data set B.

The R value showed a moderate correlation for the relationship between CBM scores and math SBAC scores for data set A (0.674) and for data set B (0.672). Based on the results from the regression analyses and ANOVA tests, I rejected the null hypothesis that there would be no significant prediction of math SBAC scores in third, fourth, or fifth grade by fall math CBM scores. Instead the data says that the full model accounts for a statistically significant percentage (about 45%) of the variance of SBAC scores. Tables 14 and 15 summarize the regression results.

Table 16
ANOVA Data Set A

Model 3		Sum of Squares	df	Mean Square	F	Sig.
	Regression	11697121.844	6	1949520.307	378.941	.000
	Residual	14034632.242	2728	5144.660		
	Total	25731754.086	2734			

Table 17
ANOVA Data Set B

Model 3		Sum of Squares	df	Mean Square	F	Sig.
	Regression	11629953.469	6	1938325.578	374.539	.000
	Residual	14143891.763	2733	5175.226		
	Total	25773845.232	2739			

CBM scores in data set A were found to have a statistically significant unstandardized coefficient ($\beta = 4.747$, $p < .01$). This means that for each additional point on a CBM, participants on average received 4.7 additional points on mathematics SBAC. In data set B, CBM scores were found to have a statistically significant unstandardized coefficient ($\beta = 4.414$, $p < .01$). This means that for each additional point on a CBM, participants on average received 4.4 additional

points on mathematics SBAC. Table 18 and Table 19 summarize the findings of the unstandardized coefficients.

Table 18
Coefficients for Independent Variables for SBAC Mathematics Scores for Data Set A

	Unstandardized Coefficients		Standardized Coefficients		
	β	Std. Error	B	*T*	Sig.
(Constant)	2468.266	2.970		831.038	.000
SPED Status	-57.924	4.927	-.170	-11.757	.000
ELL Status	-80.373	5.228	-.242	-15.373	.000
Hispanic Vs. All Others	-35.979	3.462	-.167	-10.392	.000
Others Vs. White and Hispanic	-14.313	4.080	-.052	-3.508	.000
Gender	-6.828	2.776	-.035	-2.460	.014
CBM Test Score	4.747	.154	.458	30.774	.000

Table 19
Coefficients for Independent Variables for SBAC Mathematics Scores for Data Set B

	Unstandardized Coefficients		Standardized Coefficients		
	β	Std. Error	B	*T*	Sig.
(Constant)	2462.697	3.107		792.696	.000
SPED Status	-57.735	4.934	-.169	-11.701	.000
ELL Status	-80.187	5.243	-.241	-15.295	.000
Hispanic Vs. All Others	-36.428	3.467	-.169	-10.507	.000
Others Vs. White and Hispanic	-13.828	4.090	-.050	-3.381	.001
Gender	-7.194	2.781	-.037	-2.587	.010
CBM Test Score	4.414	.145	.454	30.430	.000

2. *To what extent does gender interact with mathematics CBM scores to predict mathematics SBAC scores?*

Hierarchical multiple regression was run to determine the extent to which gender helped predict mathematics SBAC scores. For data set A the addition of gender to the prediction of SBAC (Model 2) led to a statistically significant increase in R^2 of .006, $F(1, 2729) = 22.211$, $p < .001$ (LAERD, 2015). For data set B the addition of gender to the prediction of SBAC (Model 2) led to a statistically significant increase in R^2 of .006, $F(1, 2734) = 22.299$, $p < .001$ (LAERD,

2015). For both data set A and B this means that the addition of gender to the model only accounts for 0.6% of the variance in SBAC scores. Therefore, I rejected the null hypothesis that there would be no significant prediction of mathematics SBAC scores by gender. Even though the correlation was statistically significant, the R^2 change value for both data sets indicates that only 0.6% of the variance in SBAC scores can be explained by gender. This suggests that gender is a weak predictor of math SBAC scores.

Gender was found, in data set A, to have a statistically significant unstandardized coefficient ($\beta = -6.828$, $p < .05$). This means that participants who were classified as female were found to have on average scores that were 6.8 points lower than participants who were classified as male. In data set B, gender was found to have a statistically significant unstandardized coefficient ($\beta = -7.194$, $p < .05$). This means that participants who were classified as female were found to have on average scores that were 7.1 points lower than participants who were classified as male (see coefficient Tables 18 and 19 above). While six or seven points might not seem to be a lot, those points could be the difference between meeting or not meeting grade level standards.

3. *To what extent do mathematics curriculum-based measurements taken in the fall, together with demographic factors for ethnicity, special education status, and English language learner (ELL) status, predict mathematics SBAC scores taken at end-of-year in the third, fourth, and fifth grades?*

In model 1, where the variables for ethnicity, special education status, and English language learner status were the only variables in the regression analysis, the *R* value was .509. This indicated a positive correlation between these demographic variables and mathematics SBAC scores. Putting ethnicity, special education status, and English language learner status into the regression to predict SBAC (Model 1) led to a statistically significant R^2 of .259, $F(4, 2730)$

= 238.868, $p < .001$ for data set A and a statistically significant R^2 of .259, $F(4, 2735) = 239.377$, $p < .001$ for data set B. In other words, the variables of ethnicity, SPED status, and ELL status account for about 25% of the variance in SBAC scores in both data set A and data set B. Therefore, I rejected the null hypothesis that there would be no significant predication of mathematics SBAC scores by ethnicity, special education status, or English language learner status.

In data set A, the ethnicity category of Hispanic was found to have a statistically significant unstandardized coefficient ($\beta = -35.979$, $p < .001$) showing that for participants classified as Hispanic, their SBAC score was on average 35.9 points lower than participants classified as all other ethnicities. Data set B was also found to have a statistically significant unstandardized coefficient ($\beta = -36.428$, $p < .001$) showing that for participants classified as Hispanic, their SBAC score was on average 36.4 points lower than participants classified as all other ethnicities. For the ethnicity categorization of Other (including participants classifying as Native Hawaiian/Other Pacific Islander, Asian, Two or More, Black/African American, and American Indian/Alaskan Native) there was a statistically significant unstandardized coefficient ($\beta = -14.313$, $p < .001$) for data set A. This shows a trend that when classified as Other, SBAC scores on average were 14.3 points lower than those classified as Hispanic and White. For data set B there was also a statistically significant unstandardized coefficient ($\beta = -13.828$, $p < .001$). This shows a trend that when classified as Other, SBAC scores on average were 13.8 points lower than for those classified as Hispanic or White.

Special education status, in data set A, was found to have a statistically significant unstandardized coefficient ($\beta = -57.924$, $p < .001$) showing that for participants classified as receiving special education services, their SBAC score was on average 57.9 points lower than

participants who were classified as not receiving special education services. For data set B, special education status was also found to have a statistically significant unstandardized coefficient ($\beta = -57.735$, $p < .001$) showing that for participants classified as receiving special education services, their SBAC score was on average 57.7 points lower than participants who were classified as not receiving special education services.

ELL status, for data set A, was found to have a statistically significant unstandardized coefficient ($\beta = -80.373$, $p < .001$) showing a trend that when classified as an ELL participants scores were on average 80.3 points lower on math SBAC than participants not classified as ELL. ELL status, for data set B, was also shown to have a statistically significant unstandardized coefficient ($\beta = -80.187$, $p < .001$) showing a trend that when classified as an ELL participants scores were on average 80.1 points lower on math SBAC than participants not classified as ELL.

Conclusion

Interesting findings emerged from the regression analyses. First, the full model of independent variables accounted for 45% of the variance in SBAC scores. This is not a small percentage to be overlooked. Ethnicity, gender, ELL status, and SPED status, in conjunction with CBM scores, can provide information to educators on how students might perform on SBAC.

The regression analyses also revealed some interesting data surrounding SPED status. There is often a stigma that students who qualify for Special Education perform worse than their peers who are not receiving SPED services. While the data showed that students receiving SPED services scored, on average, 57.9 points (data set A) and 57.7 points (data set B) lower than their non-SPED peers, there was also information that contradicted the idea that SPED students underperform. In casewise diagnostics, it was found that more participants with a SPED

diagnosis were outliers because of their high scores than there were outliers of students with SPED qualification because of low scores.

It is also interesting to note that participants with ELL status were more likely to have lower scores than their non-ELL peers compared to students with SPED qualification. The data showed that students qualifying for ELL status, on average, scored 80.3 points (data set A) and 80.1 points (data set B) lower than their non-ELL peers. This is a larger discrepancy in points than those students with a SPED qualification and their non-SPED peers.

The following chapter discusses the above findings of this study. It includes implications of the findings, recommendations for use of the findings as well as for further research, and limitations of the study.

Chapter Five: Discussion

The purpose of this study was to determine the predictive validity of math computation curriculum-based measurement (CBM) scores on mathematics Smarter Balanced Assessment Consortium (SBAC) scores for students in third, fourth, and fifth grade in the Elk Ridge School District during the 2017-2018 school year. The following chapter includes a discussion of the findings, limitations of the study, implications for practice, and suggestions for future research.

This study began with a current problem of practice. I was continually seeing my students come to upper elementary grades unprepared to tackle the math the Common Core State Standards requires of them. I noticed that students who did not have a firm grasp on basic facts of the four operations struggled as math concepts grew increasingly more difficult. I designed this study out of my observation and concern about this issue, since it falls to me, as a classroom teacher, to build a case on behalf of students who needs additional support beyond what the general education classroom can offer. This study held the potential to further inform my practice using CBM as a predictive tool for SBAC scores, enabling me to ascertain their usefulness and relevance to my instructional practice.

Educational support personnel often advocate for additional testing when academically at-risk students are referred to them. However, I believe, based on the results of this study, that there is already sound assessment data that might be able to offer the critical information needed for additional support. This seems like an important first step before subjecting students to further testing. I became curious if the testing that we already had in place might provide the clues we would need to deliver support early in the year. Specifically, I wondered if math computation CBM (a testing measure already in use) could be helpful as one piece of the puzzle in building a case for students who need more support. The current accountability climate in

education leans heavily into the end-of-the-year summative testing; in this case SBAC. If CBM scores could help predict SBAC scores, perhaps this data could help educators build a case, along with other measures, for students to receive additional intervention earlier in the year, thus allowing them more time to grow their skills prior to the end-of-year SBAC exam. Thus, this study offers classroom teachers and administrators critical information regarding the relationships between CBM and SBAC.

Research Question One

To what extent do mathematics curriculum-based measurements taken in the fall predict mathematics SBAC scores taken at end-of-year for students in third, fourth, and fifth grade?

There was a statistically significant ($p < .001$) moderate, positive correlation between CBM scores and math SBAC scores (R=.674) for data set A, which included third-grade multiplication CBM, fourth-grade division CBM, and fifth-grade multiplication and division combined CBM. The adjusted R^2 value was 0.453, meaning that about 45% of the variability of SBAC scores could be attributed to the full model of CBM scores, gender, ethnicity, SPED status, and ELL status. There was a statistically significant ($p < .001$) moderate, positive correlation between CBM scores and math SBAC scores (R=.672) for data set B, which included third-grade multiplication CBM, fourth-grade multiplication CBM, and fifth-grade multiplication and division combined CBM. The adjusted R^2 value was 0.450, meaning that about 45% of the variability of SBAC scores could be attributed to the full model of CBM scores, gender, ethnicity, SPED status, and ELL status. This shows that CBM scores, in conjunction with demographic factors for ethnicity, gender, SPED status, and ELL status have modest predictive power of math SBAC scores. Looking at the standard error can also be important. The standard error decreased with each model in both data sets. For data set A, the standard error for model 3

was 71.726, and for data set B, the standard error was 71.939. These standard errors suggest that actual scores varied somewhat from predicted scores. Educators can expect that 95% of students would fall within plus or minus two standard deviations of the standard error. Knowing this information is important when looking at an entire class (school or district) to be able to determine the accuracy of the model.

The addition of CBM scores to the model showed a statistically significant ($p < .001$) increase in R^2 of .189 for data set A and .186 for data set B. This means that CBM scores, for both data sets, contributed a total of 18% of explained variance to SBAC scores. Thus, CBM scores have a small to moderate strength of effect (Cohen, 1988; Meyers, Gamst, Guarino, 2017).

These findings align to previous findings by Chafin et al., (2015) that looked at math CBM and its predictive power on end-of-year testing in second grade, and third grade performance on the Georgia mathematics test. The results also support previous research that show fact fluency allows students to be able to work towards completing more complex mathematical tasks (McCallum, Skinner, Turner & Saecker, 2006; Reed et al. 2015) and that computational fluency is important for mathematics tasks of greater difficulty (Tolar, Lederberg, & Fletcher, 2009).

Implications. These particular findings have implications for district leadership and administrators as well as for classroom teachers. District administrators can provide leadership that helps teachers learn to identify skill areas that have a pattern of weakness and then provide resources and professional development to support these areas. Results of this study indicate that administrators could help boost math SBAC scores by encouraging teachers to use CBM scores to advocate for students needing additional support. For classroom teachers, these findings point

to the importance of including fact fluency practice into the school day. Following a discussion about the remaining two research questions, implications and suggestions for practical solutions are presented.

Research Question Two

To what extent does gender interact with mathematics CBM scores to predict mathematics SBAC scores?

For data set A and data set B the addition of gender to the prediction of SBAC led to a statistically significant ($p < .001$) R value of .515, with an R^2 change value of 0.006. This means that the addition of gender to the model only accounted for 0.6% of the variance in SBAC scores. This suggests that gender is a weak predictor of math SBAC scores. Participants classified as female were found to have, on average, scores that were 6.8 points lower (data set A) and 7.1 points lower (data set B) than participants who were classified as male. These findings align with previous research showing that at the elementary level, males and females generally perform at the same level (Leahey & Guo, 2001; Steele, 2003).

Implications. As a classroom teacher, these findings are encouraging. They indicate that students, both male and female, are capable of exceeding in math and that current teaching practices are supporting both genders. Seeing that female participants scored 6.8 points below (data set A) and 7.1 points below (data set B) their male counterparts, it seems important to keep in mind that females have been found to hold less positive attitudes towards math than males (Else-Quest, Hyde, & Linn, 2010), and that by second grade some students have developed the concept that "math is for boys" (Markovits & Forgasz, 2017). The good news is that even though girls tend to underestimate their own math abilities, these underestimations can take several years to develop and teachers and parents can be influential in how students think about their own

math abilities (Herbert & Stipek, 2005). Teachers can model an appreciation for math, point out its real-world applications, and encourage a growth-mindset. Beilock, Gunderson, Ramirez, & Levine (2009) found that negative emotions about mathematics that elementary teachers held predicted the achievement of girls in their classes, but did not predict the achievement of boys. Exploring gender differences in mathematics Boaler (2016) writes:

> This gender difference probably comes about because girls identify with their female teachers, particularly in elementary school. Girls quickly pick up on teachers' negative messages about math-the sort that are often given out of kindness, such as: 'I know this is really hard, but let's try and do it' or 'I was bad at math at school' or 'I never liked math'. (p. 9).

Elementary teachers, many of whom are female, can help set students up for success in math by exhibiting a growth mindset. Continuing to grow programs based in mathematics such as STEAM (science, technology, engineering, art, and math) at the elementary level can help all of our students, including our female students, see themselves using mathematics in their lives.

Research Question Three

To what extent do mathematics curriculum-based measurements taken in the fall, together with demographic factors for ethnicity, special education status, and English language learner (ELL) status, predict mathematics SBAC scores taken at end-of-year in the third, fourth, and fifth grades?

Putting ethnicity, special education status, and English language learner status into the regression to predict SBAC resulted in a statistically significant ($p < .001$) R of .509 for both data set A and data set B. The R^2 of both data sets was .259. In other words, the variables of ethnicity, SPED status, and ELL status account for about 25% of the variance in SBAC scores in

both data set A and data set B. Thus, taken in combination, ethnicity, SPED status, and ELL status, contribute to educators' ability to predict students' math SBAC scores.

Ethnicity. The data showed that participants classified as Hispanic scored, on average, 35.9 points (data set A) and 36.4 (data set B) below their peers classified in any other ethnicity category. This is consistent with data collected on SBAC by the Oregon Department of Education (2017b) and data collected nationally on the National Assessment of Educational Progress test (McFarland et al., 2018). This data is alarming. Policymakers, administrators, and teachers must do more to close the achievement gap between Hispanic students and non-Hispanic students. When students of color struggle, educators should turn to proven equitable practices to help close the gap. Boaler (2016) suggests six strategies for making mathematics education more equitable. They include: (1) offer all students high-level content, (2) work to change ideas about who can achieve in mathematics, (3) encourage students to think deeply about mathematics (including hands-on experiences, project-based curriculum, curriculum with real life applications, and opportunities to work together, (4) teach students to work together, (5) give girls and students of color additional encouragement to learn math and science, and (6) eliminate, or at least change the nature of, homework (p. 102-107). The success of Boaler's six strategies must be laid over the foundation of strong teaching practices. Strong teaching practices that benefit students who struggle are strong teaching practices for all.

English language learners. Students who were classified as English language learners scored, on average, 80.3 points (data set A) and 80.1 points (data set B) below their peers who did not qualify as English language learners. This data is also consistent with data collected on SBAC by the Oregon Department of Education (2017b). It is consistent too with the 2017 NAEP findings (McFarland et al., 2018). Both the results of this study as well as those from the Oregon

Department of Education, and national data provided by NAEP show that ELLs lag behind their native English speaking peers in standardized mathematics assessments. This data paints a bleak picture. As America's ELL population continues to increase, measures must be taken to help ELL students be successful. Freeman and Freeman (2011) suggest the following to help ELL students be successful, all of which could be integrated into the Elk Ridge School District: ELLs are shown to be more successful in schools…

- Where there is strong ELL parent involvement.
- When schools offer high-quality after school programs.
- Where teaching strategies are based heavily in modeling, scaffolding, and guided practice.

In addition, specific teaching strategies need to be implemented into schools to address the needs of the ELL population, with the goal of closing the achievement gap. Echevarria, Vogt, and Short (2013) suggest implementation of specific strategies that intentionally target the achievement gap for ELL students. Some of these strategies include, providing hands-on manipulatives for practice, clearly defining, posting, and reviewing content and language objectives with students, and explicitly teaching academic mathematics vocabulary. Again, good teaching practices for students who struggle are good teaching practices for all.

Special education. Students who qualified for SPED scored, on average, 57.9 (data set A) and 57.7 (data set B) points less than their peers who did not qualify for SPED. This finding is also consistent with the findings of the Oregon Department of Education (2017b) that show that students who qualify for SPED are less likely than their non-SPED peers to meet proficiency standards in math.

It is interesting to note that students who qualified as ELLs had a greater disadvantage than those who qualified for SPED. Casewise diagnostics also revealed unexpected information about students receiving SPED services. The majority of the outliers for students with a SPED qualification were due to high scores, not low scores. There seems to be a stigma around Special Education, where some believe that students with this qualification must be intellectually disabled. However, intellectual disability is only one of eleven SPED eligibility disabilities. The other ten include (1) hearing impairment, (2) vision impairment, (3) deafblindness, (4) communication disorder, (5) emotional disturbance, (6) orthopedic impairment, (7) traumatic brain injury, (8) other health impairment, (9) autism spectrum disorder, and (10) specific learning disability (Oregon Department of Education, 2019). The findings of this study support the fact that SPED qualification is not always synonymous with lowered intellectual capability or math achievement. These findings show the demographic factors our students enter our schools with, must become a priority in planning and teaching for students to succeed.

Implications for Practice

This study has limited generalizability due to the fact that it was conducted in only one school district with a distinct population. It would be unwise to make sweeping recommendations based on the findings of this study. However, I do believe this study and its findings are important, and can offer some guidance for educators moving forward. The findings of this study have implications for the school district in which it was conducted, educational policymakers, and in particular, classroom teachers.

Implications for the Elk Ridge School District. Elk Ridge School District should look to the mean CBM scores (10.27 for data set A, and 12.35 for data set B) from this study as a starting place for implementing instructional practices and support around helping students

master their basic facts. This means that, on average, students in the Elk Ridge School District are solving between 10 and 12 problems a minute. To show procedural fluency, solving one problem every three seconds, or a minimum of 20 problems in a minute is expected. This means students in the Elk Ridge School District are well below the threshold for procedural fluency.

Simply continuing the practice of timed tests is not a solution to the problem of students not being able to recall with automaticity their basic facts. In fact, research suggests that timed tests can create anxiety about mathematical learning (Boaler, 2016; Kling & Bay-Williams, 2014) that might actually reduce performance. The district should research effective programs and strategies for helping students learn and retain basic facts.

Technology can be leveraged to help students practice fact fluency skills. Computer programs can individualize practice and instruction that is either impossible or extremely time consuming for educators to do (Musti-Rao & Plati, 2015; Nelson, Burns, Kanive, & Ysseldyke, 2013; Poncy et al., 2013). Immediate feedback is important for learning basic facts (Hawkins, et al., 2017; Musti-Rao & Plati, 2015; Poncy et al., 2010) and computer programs can offer this instantaneous feedback to students (Hawkins et al., 2017). Other considerations when selecting a computer-adapted program for increasing math fluency are pacing, student engagement, and the programs ability to generate individualized progress reports for the teacher (Hawkins et al., 2017). A few programs currently on the market that could be vetted for consideration include Reflex, Quick Math, and Math Fact Fluency.

Elk Ridge School District should consider finding ways to provide support for teachers, support staff, and parents in assisting students to develop these skills. “The very best way to encourage the learning of facts and the development of a mathematical mindset is to offer conceptual mathematical activities that help students learn and understand numbers and number

facts" (Boaler, 2016, p. 39). With this in mind, new strategies should be researched for implementation. The current curriculum does not do enough to fill the gap in math fact learning, and more must be done. Knowing the importance of fact fluency, educators must wisely choose interventions to support students' basic fact knowledge. When educators are selecting tasks to increase fact fluency, they should select activities where students must produce answers. Interventions should give students multiple opportunities to respond (Hawkins, Collins, Hernan, & Flowers, 2017; Musti-Rao & Plati, 2015). Studies conducted over the last ten years look at the impact of specific interventions on students' fact fluency (Nelson et al., 2013; Poncy, Fontenelle IV, & Skinner, 2013; Rave & Golightly, 2014; Reed et al., 2015; Walker et al., 2013). The following interventions could be considered for implementation:

- Detect, Practice, and Repair (DPR). A study by Poncy et al. (2013) found the DPR method was useful for differentiating fact fluency instruction to meet the needs of individual learners. DPR is a three-phase intervention where students detect their mistakes, practice those facts, and repair the answers.
- Rocket Math. In a non-experimental design pre-test post-test study, it was found the Rocket Math program helped 93% of forty-four fifth-graders increase the number of problems they could solve in two minutes, after participating in nine weeks of the intervention (Rave & Golightly, 2014).
- Taped-problems (TP). Developed by Skinner, McCallum, and Hutchins (2004), a TP procedure includes a worksheet with a variety of targeted fact problems. An audio recording presents each problem on the page ("6 x 8 is…"), there is a two second delay, and the answer is given. Students are instructed to "beat the tape" by writing the answer before the audio tape reveals the correct response (Poncy et

al., 2015). TP was found to be an effective class-wide fluency intervention (Poncy et al., 2015).

Students need multiple opportunities to practice throughout the day (Schutte et al., 2015). Multiple interventions can work for students, from technology-based interventions (Musti-Rao & Plati, 2015), to individualized interventions (Poncy et al., 2013) to whole class interventions (Poncy et al., 2015; Schutte et al., 2015). It is the job of district leadership to provide teachers, parents, and students with effective programming.

Implications for policymakers. Whether headed for college or career, it is difficult to think of a situation in which all of our students would not benefit from having a strong grip on the basics of mathematics. The results of this study showing the large disparities in SBAC scores between students who qualify for ELL status and those who do not, should raise concern for policymakers. Each year the number of ELL students entering American classrooms is increasing. For the educational system to be successful, ELL students must be successful. Second language acquisition educators need strong policies in place to help protect and support ELL students. This includes putting teachers in the classroom who have training in working with ELL students. "The number of English learners has increased without a comparable increase in ESL or bilingual certified teachers" (Echevarria, Vogt, and Short, 2013, p. 7). We need policies that allow our ELL students access to language support services until they are proficient not only in conversational English, but also in academic English, something that usually takes four to seven years. Strong support programs need to be in place at every school.

Implications for classroom teachers. I believe this study supported what many classroom teachers have suspected for a long time, that if students have not mastered their basic math facts, it is difficult for them develop deep understanding around more complex

mathematics concepts. Geary (1994) says that the ability to have math fact fluency can lead to being successful in higher order mathematics; automaticity allows students to free up working memory that they can then devote to complex problem solving and the ability to learn new concepts.

I find the results of this study hopeful for classroom teachers. This study showed that 18% of the variance in SBAC scores could be attributed to CBM scores. While this is a moderate effect size, I believe it is enough to help educators build a case for students who need additional support. Christ, Scullin, Tolbize, & Jiban (2008) caution against using CBMs for non-screening-type decisions. However, this study points to the usefulness of CBM scores as one part of a portfolio that is presented when a teacher is making a case for intervention for an individual student. When an educator is concerned about a student's ability or progress in mathematics, it generally falls to that teacher to provide evidence of an ongoing problem before asking that the student be provided extra support. This evidence can include classroom assessments, both summative and formative, student work, anecdotal evidence, and test scores-such as an SBAC score from the previous year. Including CBM scores with this evidence could be helpful in creating an overall picture of how the student is doing. CBM scores, in conjunction with other evidence, could help make a case of necessary support for a student.

CBM scores could also be helpful in the individual classroom. Some teachers already choose to use CBM scores to inform their decision making in the classroom, some do not. I believe that the results of this study support using fall CBM scores to inform practice. If, for instance, CBM scores are low for an entire class adding five minutes of intentional fact practice into the day for all students could be helpful in preparing them to take on more complex subject matter. It would be exciting if the time invested by teachers and students in test taking would

correlate to specific information available to support individual student growth in math. I believe this is what looking at fall CBM scores can do for informed practice. The information becomes a tool for adjusting basic methods and strategies. It is also information to encourage parents to support math fact practice at home. Basic fact practice does not require knowledge of new math methods or of the English language two reasons parents often cite for not being able to support mathematics work at home. Basic math facts are an area where most parents are comfortable, and can build community between school and home to support student success, particularly for our most vulnerable students.

Limitations

One limitation of this study was that it only focused on one school district. Therefore, the results might not be useful to school districts whose population varies greatly from that of the Elk Ridge School District. Another limitation of the study was that it looked at third-, fourth-, and fifth-grade scores together. It would be interesting to see if segregating out grade-level results would change the predictive validity results of CBMs on SBAC. It would be interesting to see if, over time, CBMs became more predictive of SBAC since as the standards build they rely more heavily on the assumption that students have their basic facts memorized.

As mentioned in Chapter 1, both CBMs and SBAC are administered by individual educators. For this reason, there could be differences in how the tests are administered from classroom to classroom and school to school, even within the same district. Also, SBAC is still a relatively new assessment. With its first implementation in 2015, the data used for this study represented only the fourth year of SBAC scores. With a limited history, reliability, validity, and bias for this test can be called into question.

An additional limitation of this study was that it was unable to use socioeconomic status as a variable. In the original plan, SES data operationalized as free and reduced lunch status was going to be included as an independent variable. Even though SES data was requested, it was unable to be obtained. It would be interesting to repeat this study including SES and see how the results might differ particularly in light of the fact that SES has been shown to impact student scores on standardized assessments (Oregon Department of Education, 2017b).

Suggestions for Future Research

The replication of this study holds promise for other school districts as they seek to understand the relationships between formal and informal math assessments. It would be interesting to see how the results compare to districts that have populations that differ greatly from that of the Elk Ridge School District. It would be valuable information to look at the predictive validity of CBMs on SBAC scores in districts with both less vulnerable and more vulnerable populations. Replicating this study statewide could also provide valuable information.

It would be possible to see if predictive validity of CBMs on SBAC differs by grade level. This study could be replicated with only third, only fourth, or only fifth grade scores. I wonder if predictive validity increases, decreases, or stays the same as students progress through grade levels.

This study looked at CBMs given in the fall. CBMs are given again in both the winter and the spring. It would be worth investigating the predictive validity of math CBMs given in the winter on math SBAC scores. Winter CBMs, given in January, could still provide educators time to make changes to instruction, or intervention, before the administration of SBAC in the spring. It would be curious to see if CBMs given in the winter, closer to the administration of SBAC, would contribute a higher variability of prediction to SBAC scores. It could also be argued that

fall CBMs could be impacted by what educators refer to as the "summer slide," where students' test scores tend to be lower in the fall because of the lack of practicing skills over the summer. Winter CBMs might mitigate some of these effects.

Future research should also focus on other ways to identify struggling students in the area of mathematics for the purpose of providing them with extra support. I advocate for further research exploring ways to identify struggling learners without adding to the already high testing burden placed on students and teachers.

In addition, there would be value in research that focuses on teaching practices, strategies, and programs for students who are struggling with learning basic facts. There are many computer-based programs claiming strong results, but the research behind these programs is lacking. How can we best get individualized instruction in the area of math facts to our students?

Conclusion

All students deserve a quality education. All students deserve an equitable education, but that does not mean an equal education. Educators have the job of determining their students' current ability level and crafting a plan for helping each individual be successful. For some students this means finding ways to push them past the requirements of the CCSS, for others it means guiding them towards meeting their grade levels' CCSS, for still others it means finding ways to intervene to provide extra support before the gap widens between their current ability and the grade level expectations. This means utilizing strong teaching practices, research-informed pedagogy, and individualizing instruction. There are students for whom what an individual educator can provide in the classroom will not be enough. It then becomes the educator's job to advocate extra, often specialized instruction for that student. This requires

building a case for resources to be allocated to this task. The predicative validity of CBMs means they can be used as a tool, in conjunction with other means of data collection, to help educators build a case for helping our most vulnerable students.

Moving forward, I would suggest caution. A student scoring high on CBM may still need extra support, a student scoring low on CBM might have been having a bad day. Diligence in making recommendations for how to support students is paramount. The results of this study offer several reasons for educators to embrace hopefulness as they seek to improve math achievement of all students. Hopeful that there are ways to build a strong case for helping our most vulnerable students, that all students can have an education tailored to their needs, and that all students can find success in mathematics.

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Appendix A

Third-grade Fall 2017 CBM

Student Name:
ID #: School:
Teacher: Grade: 3rd Grade

Total # Correct:

0 x 2	0 x 6	0 x 1	8 x 8	2 x 0	9 x 9	6 x 9
8 x 1	0 x 1	4 x 6	4 x 5	5 x 2	7 x 6	6 x 6
6 x 7	0 x 8	2 x 4	7 x 5	11 x 9	10 x 8	8 x 8
11 x 2	1 x 7	8 x 4	0 x 7	7 x 8	0 x 4	9 x 3
2 x 9	4 x 2	12 x 5	5 x 1	5 x 5	7 x 5	12 x 6
4 x 2	1 x 1	7 x 4	7 x 0	9 x 8	6 x 6	2 x 4

Grade 3_Fall Benchmark Page 1 of 2

Keep Going

4 x 4	2 x 1	10 x 3	10 x 11	4 x 7	10 x 8	3 x 6
1 x 7	12 x 7	5 x 8	8 x 5	3 x 9	9 x 9	1 x 8
12 x 3	2 x 8	8 x 5	8 x 4	11 x 5	5 x 0	5 x 3
9 x 5	5 x 2	9 x 8	12 x 3	5 x 3	5 x 7	8 x 6
1 x 8	2 x 2	0 x 9	12 x 1	5 x 7	1 x 2	6 x 5
4 x 5	0 x 7	8 x 7	2 x 3	10 x 3	3 x 9	12 x 0

STOP

AIMS web®_ Grade 3_Fall Benchmark Page 2 of 2_Multiplication #34

Appendix B

Fourth-grade Fall 2017 Multiplication CBM

Student Name:
ID #: School:
Teacher: Grade: 4th Grade

Total # Correct:

AIMSweb® Basic Multiplication Facts #36

Student Name: __________ Grade: __________ Teacher Name: __________

9 x 8	5 x 1	0 x 1	9 x 0	5 x 5	9 x 0	5 x 9
11 x 7	8 x 5	3 x 3	5 x 3	9 x 1	6 x 1	9 x 6
5 x 5	0 x 8	12 x 9	11 x 2	9 x 8	2 x 5	12 x 6
1 x 9	10 x 7	4 x 1	8 x 1	2 x 2	7 x 9	5 x 8
4 x 8	2 x 2	9 x 9	7 x 6	10 x 3	9 x 2	3 x 9
3 x 9	7 x 4	4 x 1	8 x 4	5 x 0	7 x 4	11 x 2

Page 1 of 2

Grade 4_Fall Benchmark Page 1 of 2

Keep Going

AIMSweb® Basic Multiplication Facts #36

Student Name: ____________________ **Grade:** __________ **Teacher Name:** ____________________

1 x 2	0 x 1	6 x 2	5 x 2	11 x 2	5 x 5	7 x 8
11 x 0	4 x 2	0 x 3	11 x 2	3 x 8	0 x 4	12 x 2
9 x 5	8 x 8	9 x 8	1 x 7	12 x 1	7 x 6	10 x 1
9 x 0	11 x 11	8 x 8	11 x 0	1 x 7	9 x 8	10 x 8
1 x 0	9 x 5	2 x 9	9 x 1	8 x 9	10 x 5	9 x 9
0 x 7	7 x 9	8 x 2	8 x 9	5 x 1	0 x 0	12 x 9

Page 2 of 2

AIMS web®_ Grade 4_Fall Benchmark Page 2 of 2_Multiplication #36

Appendix C

Fourth-grade Fall 2017 Division CBM

Student Name:
ID #: School:
Teacher: Grade: 4th Grade

Total # Correct:

AIMSweb® Basic Division Facts #36

Student Name: ____________ **Grade:** ________ **Teacher Name:** ____________

$7\overline{)7}$	$3\overline{)27}$	$3\overline{)6}$	$9\overline{)81}$	$9\overline{)18}$	$4\overline{)12}$	$5\overline{)30}$
$7\overline{)28}$	$5\overline{)5}$	$9\overline{)9}$	$7\overline{)7}$	$2\overline{)10}$	$9\overline{)81}$	$7\overline{)84}$
$4\overline{)36}$	$2\overline{)24}$	$6\overline{)72}$	$10\overline{)10}$	$4\overline{)8}$	$10\overline{)10}$	$2\overline{)8}$
$3\overline{)3}$	$12\overline{)84}$	$3\overline{)6}$	$1\overline{)9}$	$4\overline{)24}$	$3\overline{)27}$	$3\overline{)27}$
$9\overline{)9}$	$1\overline{)9}$	$1\overline{)9}$	$2\overline{)18}$	$2\overline{)4}$	$3\overline{)27}$	$11\overline{)121}$
$8\overline{)72}$	$2\overline{)8}$	$4\overline{)36}$	$1\overline{)9}$	$1\overline{)9}$	$6\overline{)18}$	$2\overline{)24}$

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Grade 4_Fall Benchmark Page 1 of 2

Keep Going

AIMSweb® Basic Division Facts #36

Student Name: ____________________ **Grade:** __________ **Teacher Name:** ____________________

$9\overline{)9}$	$7\overline{)63}$	$4\overline{)20}$	$8\overline{)8}$	$6\overline{)12}$	$6\overline{)42}$	$10\overline{)10}$
$2\overline{)20}$	$9\overline{)63}$	$6\overline{)42}$	$5\overline{)60}$	$4\overline{)4}$	$9\overline{)72}$	$1\overline{)2}$
$6\overline{)72}$	$5\overline{)45}$	$7\overline{)14}$	$2\overline{)2}$	$10\overline{)10}$	$8\overline{)8}$	$3\overline{)33}$
$7\overline{)35}$	$3\overline{)30}$	$11\overline{)11}$	$6\overline{)42}$	$4\overline{)36}$	$4\overline{)36}$	$6\overline{)12}$
$7\overline{)35}$	$5\overline{)10}$	$8\overline{)64}$	$3\overline{)27}$	$8\overline{)8}$	$4\overline{)4}$	$7\overline{)7}$
$1\overline{)9}$	$4\overline{)24}$	$7\overline{)42}$	$12\overline{)108}$	$3\overline{)3}$	$2\overline{)6}$	$4\overline{)48}$

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AIMS web®_ Grade 4_Fall Benchmark Page 2 of 2_Division #36

Appendix D

Fifth-grade Fall 2017 CBM

Student Name:
ID #: School:
Teacher: Grade: 5th Grade

Total # Correct:

AIMSweb® Basic Multiplication and Division Facts #36

Student Name: ________________ **Grade:** ________ **Teacher Name:** ________________

7×7	9×6	8×7	$9\overline{)45}$	9×8	$2\overline{)2}$	$8\overline{)24}$
8×4	10×3	8×8	$5\overline{)60}$	$6\overline{)30}$	$2\overline{)12}$	9×5
$5\overline{)25}$	5×9	3×4	2×7	$11\overline{)11}$	3×4	8×6
5×6	$6\overline{)54}$	$2\overline{)2}$	1×1	$9\overline{)18}$	3×9	$7\overline{)35}$
$3\overline{)36}$	$6\overline{)36}$	8×1	6×9	4×0	3×7	$6\overline{)54}$
$11\overline{)0}$	$1\overline{)5}$	8×9	$7\overline{)49}$	$7\overline{)84}$	4×1	$8\overline{)32}$

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Grade 5_Fall Benchmark Page 1 of 2

Keep Going

AIMSweb® Basic Multiplication and Division Facts #36

Student Name: ____________________ **Grade:** __________ **Teacher Name:** ____________________

5⟌10	8 x 5	8⟌72	11 x 4	11⟌132	6⟌30	5⟌60
10 x 5	1⟌9	5⟌25	6⟌54	9⟌9	3 x 2	4⟌36
9 x 4	8 x 8	3 x 8	8 x 3	4 x 5	10⟌10	5 x 2
4 x 8	1⟌9	6 x 6	12 x 8	9⟌63	12⟌12	8 x 2
4⟌24	7⟌63	2 x 5	7⟌84	9⟌36	3⟌36	2 x 0
8 x 4	7⟌21	9 x 1	2 x 8	8 x 6	4 x 9	9 x 0

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STOP

AIMS web®_ Grade 5_Fall Benchmark Page 2 of 2_Multiplication/Division #36

Appendix E

Permission to Publish Figures from SBAC Technical Report

RE: Media and Publishing Requests [#90] Inbox ×

Chris Barron <chris.barron@smarterbalanced.org> Wed, Jan 9, 9:51 AM (7 days ago)
to me

Hi Lauren:

Yes, you have permission to use the figures as described below with proper citation. Thank you for reaching out and best of luck on your dissertation.

Regards,
Chris

Chris Barron
Senior Director of Communications
360-443-0717 | chris.barron@smarterbalanced.org

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Sent: Thursday, January 3, 2019 4:46 PM
To: Smarter Balanced Media <media@smarterbalanced.org>; Chris Barron <chris.barron@smarterbalanced.org>
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Email *	lmerkel15@georgefox.edu
Your Organization	George Fox University
Your Message *	I am a doctoral student working on my dissertation. I would like permission to use Figure 4-2 and Table 2-34 from the Smarter Balanced Assessment Consortium: 2015-2016 Summative Technical Report, with proper citation in my work.

Appendix F

Figure 4
Partial Regression Plot of SBAC scores and CBM scores for Data Set A

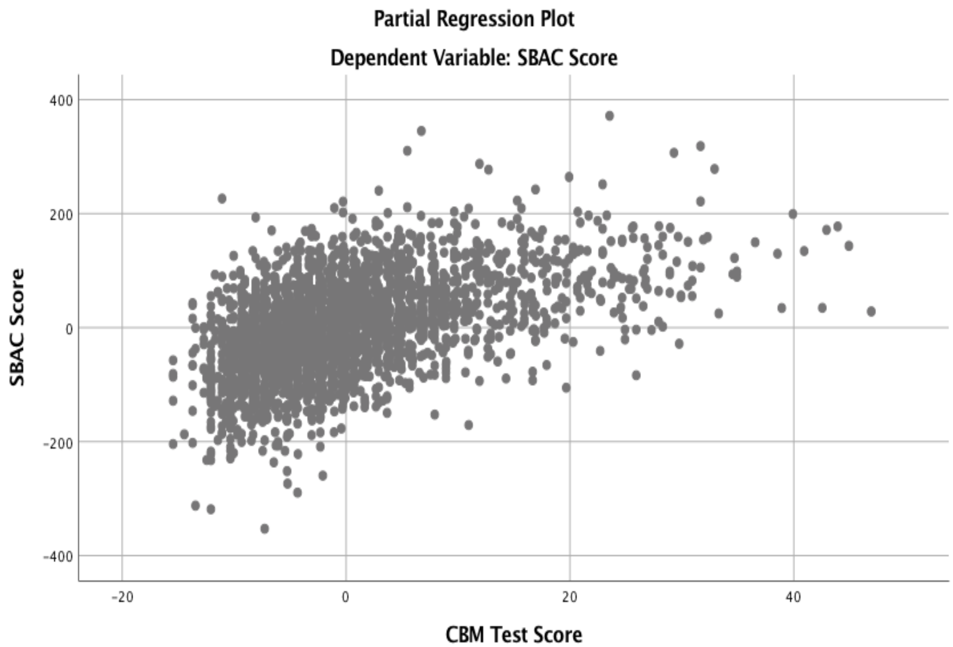


Figure 5
Partial Regression Plot of SBAC scores and CBM scores for Data Set B

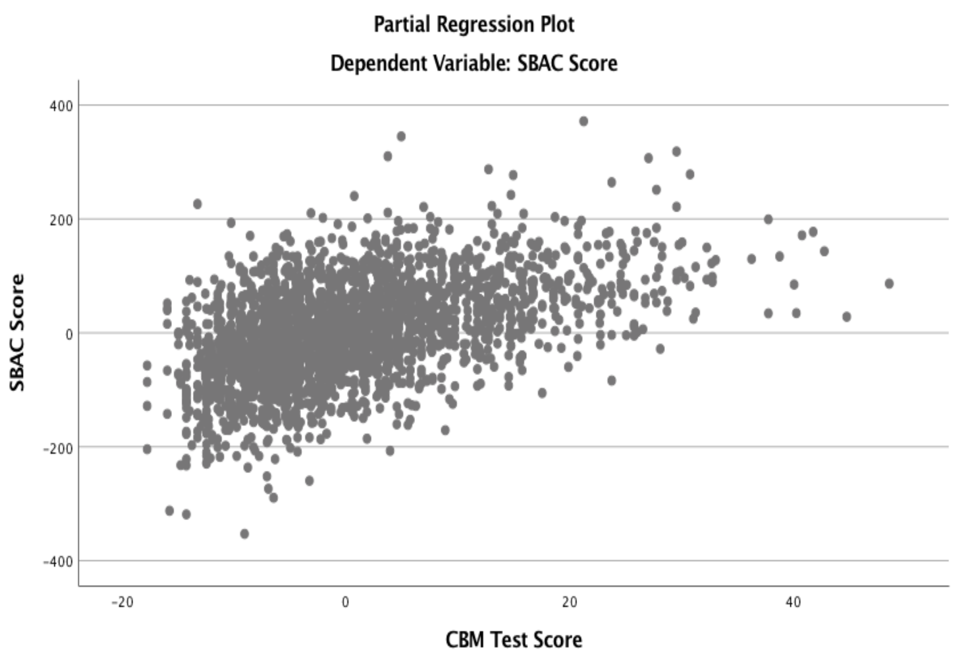


Figure 6
Plot of Studentized Residuals against Unstandardized Predicted Values for Math SBAC scores Data Set A

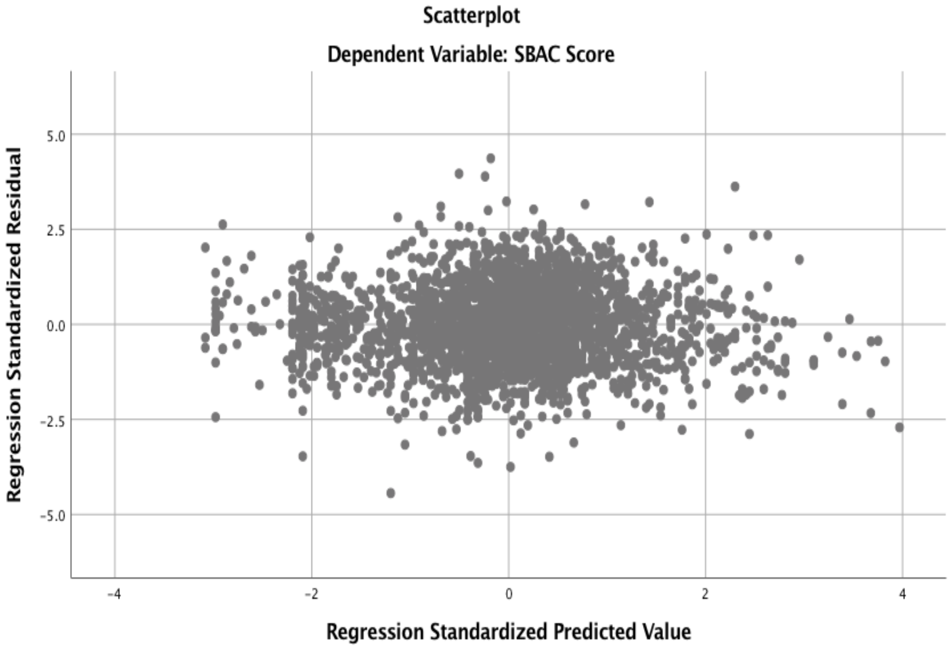


Figure 7
Plot of Studentized Residuals against Unstandardized Predicted Values for Math SBAC scores Data Set B

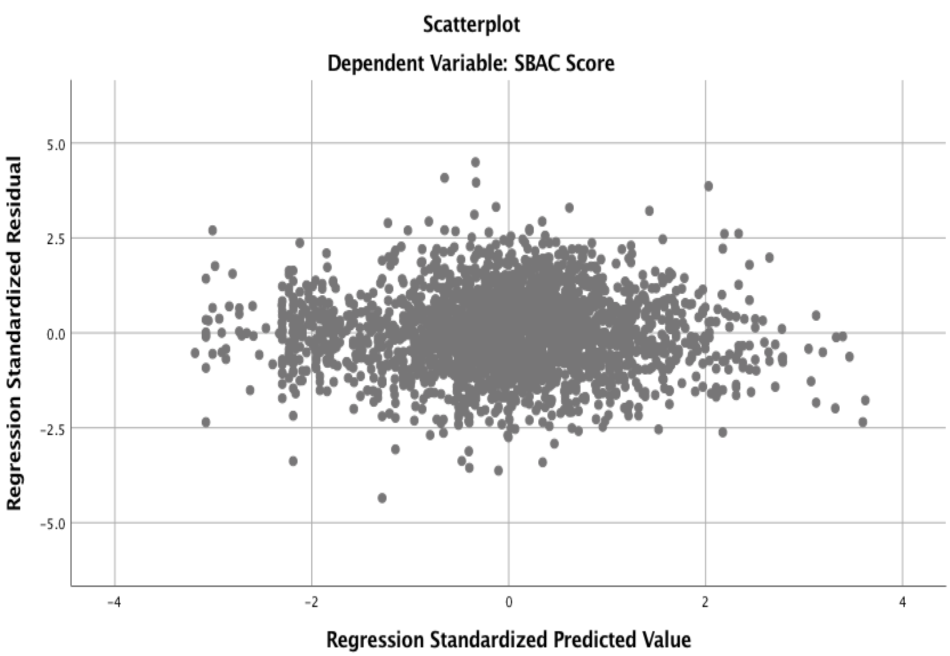


Table 20
Collinearity Statistics for Data Set A

					Collinearity Statistics	
	Standardized β	t	Sig.	Partial Correlation	Tolerance	VIF
SPED Status	-.170	-11.757	.000	-.220	.961	1.041
ELL Status	-.242	-15.373	.000	-.282	.808	1.237
Hispanic Vs. All Others	-.167	-10.392	.000	-.195	.772	1.296
Others Vs. White and Hispanic	-.052	-3.508	.000	-.067	.911	1.098
Gender	-.035	-2.460	.014	-.047	.978	1.023
CBM Test Score	.458	30.774	.000	.508	.903	1.107

Table 21
Collinearity Statistics for Data Set B

					Collinearity Statistics	
	Standardized β	t	Sig.	Partial Correlation	Tolerance	VIF
SPED Status	-.169	-11.701	.000	-.218	.960	1.042
ELL Status	-.241	-15.295	.000	-.281	.808	1.237
Hispanic Vs. All Others	-.169	-10.507	.000	-.197	.772	1.295
Others Vs. White and Hispanic	-.050	-3.381	.001	-.065	.911	1.097
Gender	-.037	-2.587	.010	-.049	.978	1.022
CBM Test Score	.454	30.430	.000	.503	.904	1.107

Figure 8

Histogram Data Set A

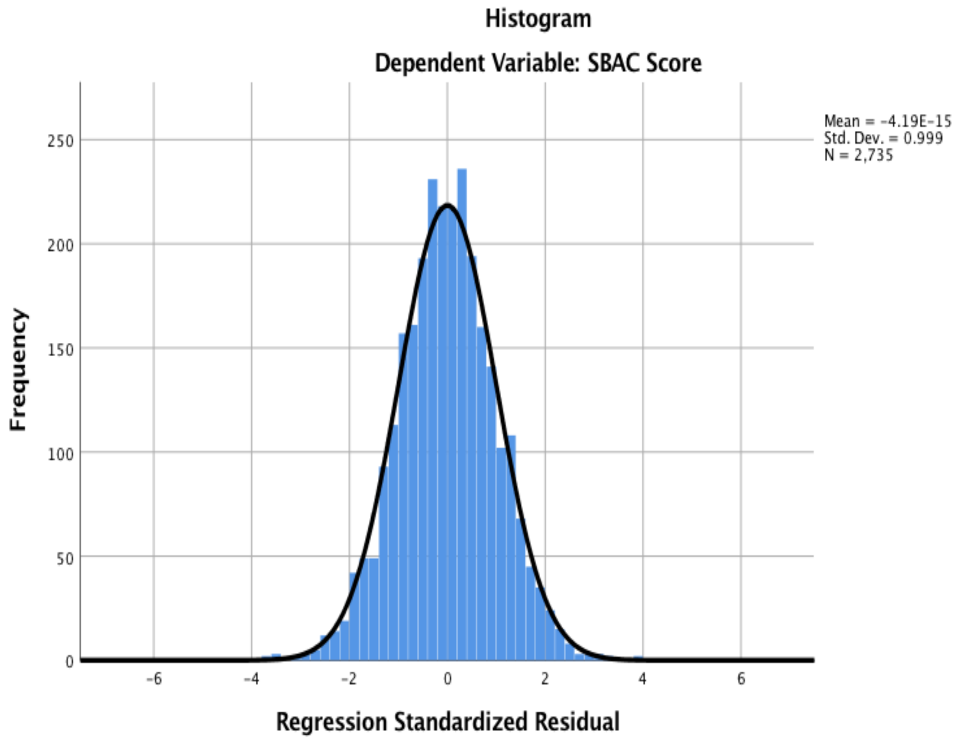


Figure 9

Histogram Data Set B

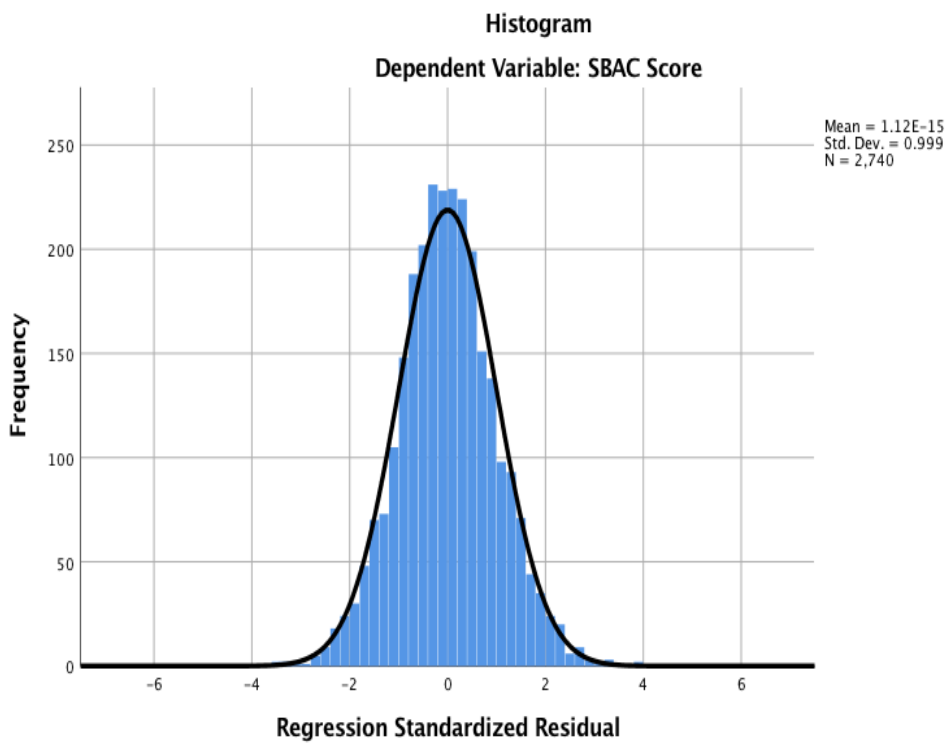


Figure 10
P-P Plot Data Set A

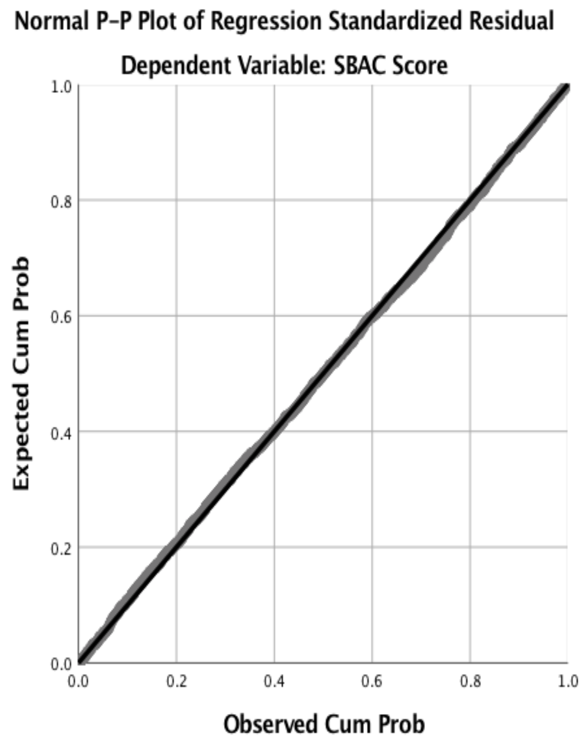
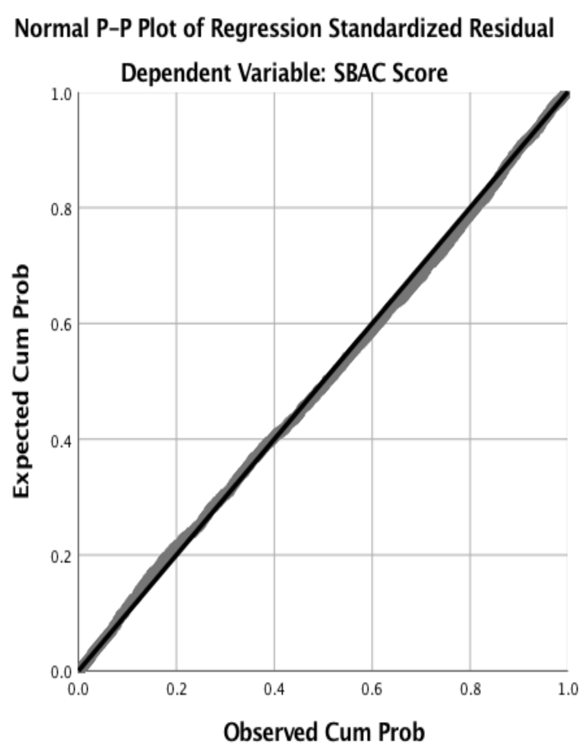


Figure 11
P-P Plot Data Set B



Appendix G

Table 22

Casewise Diagnostics for Data Set A

Case Number	Std. Residual	SBAC Score	Predicted Value	Residual
279	-3.749	2221	2489.92	-268.921
387	-4.438	2092	2410.34	-318.342
444	-3.470	2103	2351.92	-248.915
596	3.963	2740	2455.73	284.267
618	-3.109	2309	2531.98	-222.979
2007	3.101	2666	2443.57	222.427
2126	-3.464	2215	2463.45	-248.447
2179	3.021	2722	2505.29	216.714
2210	3.218	2813	2582.20	230.800
2461	4.367	2790	2476.80	313.197
2587	-3.482	2266	2515.74	-249.739
2693	-3.643	2207	2468.27	-261.266
3257	-3.163	2193	2419.84	-226.836
3259	-3.158	2766	2539.47	226.525
3408	3.624	2899	2639.09	259.905
3523	3.231	2719	2487.26	231.745
3672	3.890	2752	2473.01	278.986

Table 23

Casewise Diagnostics for Data Set B

Case Number	Std. Residual	SBAC Score	Predicted Value	Residual
279	-3.749	2221	2489.92	-268.921
387	-4.438	2092	2410.34	-318.342
444	-3.470	2103	2351.92	-248.915
596	3.963	2740	2455.73	284.267
973	-3.119	2238	2462.34	-224.344
1183	-3.374	2215	2457.70	-242.697
1267	3.213	2813	2518.87	231.126
1518	4.493	2790	2466.76	323.242
1646	-3.409	2266	2511.25	-245.251
1752	-3.554	2207	2462.70	-255.697
2319	-3.069	2193	2413.79	-220.791
2321	3.296	2766	2528.91	237.093
2470	3.864	2899	2621.01	277.986
2567	3.114	2690	2466.00	224.005
2585	3.317	2719	2480.35	238.647
2734	3.960	2752	2467.11	284.889