EFFECTS OF TEACHER BACKGROUND ON A TECHNOLOGY ENHANCED CURRICULUM:
SUCCESS FACTORS IN THE SIMCALC PROJECT

A Thesis
submitted to the Faculty of the
Graduate School of Arts and Sciences
of Georgetown University
in partial fulfillment of the requirements for the
degree of
Master of Public Policy

By

Pilar Oberwetter, B.A.

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ABSTRACT

Existing research supporting subject-area frameworks and curricular content in public education systems confirms that complex mathematics skills introduced in middle school are essential for success in high school and beyond; however, oftentimes these critical skills are not taught effectively. Teacher and curricular quality are key leverage areas for promoting student achievement and are essential to building a solid mathematical foundation for middle school students. SimCalc, a new curriculum focused on the mathematics of change and variation, combines technology and student-centered instructional processes. Using data from year one of the Scaling Up SimCalc Project, regression analysis is applied to assess the effects of teacher background on SimCalc’s impact on student achievement. The conclusions reached in this analysis show that select teacher background characteristics have no statistically significant effect on SimCalc’s impact on student achievement. These findings confirm SimCalc’s potential to be used effectively by teachers, particularly those with experience teaching math, to promote student achievement in middle school math classrooms, which should prove useful in justifying widespread use of the SimCalc curriculum.
I am grateful for the support of my peers and professors at the Georgetown Public Policy Institute (GPPI) who insisted that I could do this despite my protests to the contrary. I owe special thanks to Carolyn for encouraging me to challenge myself at GPPI, Teddy for being a sounding board at all hours (and supplying the data for this thesis), Jim for providing perspective, and E for being the distraction that kept me focused.

This thesis is dedicated to my friends and family.

Give thanks,

Pilar Oberwetter
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<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Valid N</th>
<th>Freq</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>Std Dev</th>
<th>Missing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>Whether or not participant receives treatment</td>
<td>95</td>
<td>48</td>
<td>0</td>
<td>1</td>
<td>0.505</td>
<td>0.503</td>
<td>0</td>
</tr>
<tr>
<td>group</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>Whether or not teacher is female</td>
<td>95</td>
<td>75</td>
<td>0</td>
<td>1</td>
<td>0.789</td>
<td>0.410</td>
<td>0</td>
</tr>
<tr>
<td>Highest</td>
<td>Whether or not teacher has only a Bachelor’s degree</td>
<td>93</td>
<td>76</td>
<td>0</td>
<td>1</td>
<td>0.817</td>
<td>0.389</td>
<td>2</td>
</tr>
<tr>
<td>degree</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ethnicity</td>
<td>Whether or not teacher is not Hispanic</td>
<td>95</td>
<td>73</td>
<td>0</td>
<td>1</td>
<td>0.232</td>
<td>0.424</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 2: Descriptive Statistics of Continuous Variables Reflecting Student Achievement and Teacher Background Characteristics in Scaling Up SimCalc Year One (p.16)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Valid N</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>Std Dev</th>
<th>Missing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject Area Teaching</td>
<td>Total number of years teaching the subject area of math</td>
<td>90</td>
<td>1</td>
<td>40</td>
<td>10.289</td>
<td>7.782</td>
<td>5</td>
</tr>
<tr>
<td>Experience</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>Age of teacher</td>
<td>95</td>
<td>25</td>
<td>68</td>
<td>42.632</td>
<td>9.949</td>
<td>0</td>
</tr>
<tr>
<td>Score improvement</td>
<td>Total gain from pre to and post tests</td>
<td>95</td>
<td>-1.188</td>
<td>10.833</td>
<td>4.086</td>
<td>2.611</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 3: Percent Distribution of Teacher Background Characteristics Within Treatment and Control Groups (p.17)

<table>
<thead>
<tr>
<th></th>
<th>Control Group</th>
<th>Treatment Group</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>9.47</td>
<td>11.58</td>
<td>21.05</td>
</tr>
<tr>
<td>Female</td>
<td>40.00</td>
<td>38.95</td>
<td>78.95</td>
</tr>
<tr>
<td>Total:</td>
<td>49.47</td>
<td>50.53</td>
<td>100</td>
</tr>
<tr>
<td>Non-Hispanic</td>
<td>36.84</td>
<td>40.00</td>
<td>76.84</td>
</tr>
<tr>
<td>Hispanic</td>
<td>12.63</td>
<td>10.53</td>
<td>23.16</td>
</tr>
<tr>
<td>Total</td>
<td>49.47</td>
<td>50.53</td>
<td>100</td>
</tr>
</tbody>
</table>
Table 4: Comparison of Means of Teacher Background Characteristics in Treatment and Control Groups in Scaling Up SimCalc Year One (p.17)

<table>
<thead>
<tr>
<th></th>
<th>Control Group</th>
<th>Treatment Group</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Number of Years</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teaching Math (mean)</td>
<td>9.50</td>
<td>11.04</td>
<td></td>
</tr>
<tr>
<td>Teacher’s Age (mean)</td>
<td>42.11</td>
<td>43.15</td>
<td></td>
</tr>
</tbody>
</table>

Table 5: Frequency distribution of Students Class Assignment by Test Score Increase Within Top/Bottom Quartiles in Scaling Up SimCalc Year One (p.18)

<table>
<thead>
<tr>
<th></th>
<th>Control Group</th>
<th>Treatment Group</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bottom quartile (cumulative score increase by &lt;2.06 points)</td>
<td>48.94</td>
<td>0.00</td>
<td>48.94</td>
</tr>
<tr>
<td>Top quartile (cumulative score increase &gt;6.0 points)</td>
<td>6.38</td>
<td>44.68</td>
<td>51.06</td>
</tr>
<tr>
<td>Total</td>
<td>55.32</td>
<td>44.68</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 6: Parameter Estimates for Model 1 using Scaling Up SimCalc Year One (p.19)

| Variable   | DF | Parameter Estimate | Standard Error | t value | Pr > |t| |
|------------|----|--------------------|----------------|---------|-------|---|
| Intercept  | 1  | 2.36405            | 0.28896        | 8.18    | <.0001| |
| newgroup   | 1  | 3.40848            | 0.40651        | 8.38    | <.0001| |

Table 7: Parameter Estimates for Model 2 using Scaling Up SimCalc Year One (p.20)

| Variable        | DF | Parameter Estimate | Standard Error | t value | Pr > |t| |
|-----------------|----|--------------------|----------------|---------|-------|---|
| Intercept       | 1  | 2.43928            | 0.53530        | 4.56    | <.0001| |
| newgroup        | 1  | 3.40198            | 0.41212        | 8.25    | <.0001| |
| new_tch_gend    | 1  | -0.06612           | 0.51002        | -0.13   | <.8971| |
| Hispanicnew     | 1  | -0.08529           | 0.49314        | -0.17   | <.8631| |

Table 8: Parameter Estimates for Model 3 using Scaling Up SimCalc Year One (p.21)

| Variable        | DF | Parameter Estimate | Standard Error | t value | Pr > |t| |
|-----------------|----|--------------------|----------------|---------|-------|---|
| Intercept       | 1  | 1.11368            | 1.18853        | 0.94    | 0.3513| |
| newgroup        | 1  | 3.38657            | 0.41617        | 8.14    | <.0001| |
| new_tch_gend    | 1  | 0.00821            | 0.53067        | 0.02    | 0.9877| |
| Hispanicnew     | 1  | 0.05594            | 0.51658        | 0.11    | 0.9140| |
Table 9: Parameter Estimates for Model 4 using Scaling Up SimCalc Year One (p.22)
Number of obs = 89
Adj. $R^2 = 0.4807$

| Variable    | DF  | Parameter Estimate | Standard Error | t value | Pr > |t| |
|-------------|-----|--------------------|----------------|---------|------|---|
| Intercept   | 1   | 1.94093            | 1.23521        | 1.57    | 0.1200 |
| Newgroup    | 1   | 3.47284            | 0.40613        | 8.55    | <.0001 |
| new_tch_gend| 1   | 0.04681            | 0.03619        | 0.09    | 0.9306 |
| Hispanicnew | 1   | -0.10824           | 0.52139        | -0.21   | 0.8361 |
| Newdegree   | 1   | -0.43110           | 0.52786        | -0.82   | 0.4165 |
| TCH_AGE     | 1   | -0.00570           | 0.02646        | -0.22   | 0.8300 |
| YEARS_M     | 1   | 0.07039            | 0.03297        | 2.14    | 0.0357 |

Table 10: Summary Results for OLS Regression Analysis in Scaling Up SimCalc Year One (p.23)

| Variables    | Description                                      | (1) General Model | (2) Model (1), with addition of unchanging teacher characteristics | (3) Model (2) with addition of teacher characteristics that vary | (4) Model (3) with addition of teacher characteristic that relates to teaching experience |
|--------------|--------------------------------------------------|-------------------|---------------------------------------------------------------|-----------------------------------------------------------------|
| Intercept    |                                                  | 2.365 (0.289)     | 2.439 (0.535)                                               | 1.114 (1.189)                                                  | 1.941 (1.235)                                                   |
| Newgroup     | Experimental group                               | 3.408* (0.407)    | 3.402* (0.412)                                              | 3.387* (0.416)                                                | 3.473* (0.406)                                                 |
| new_tch_gend | Teacher gender                                   | -0.066 (0.510)    | -0.008 (0.531)                                              | 0.047 (0.536)                                                 |                                                                |
| Hispanicnew  | Teacher ethnicity                                | -0.085 (0.493)    | 0.056 (0.517)                                               | -0.108 (0.521)                                                |                                                                |
| Newdegree    | Highest degree                                   |                   | -0.679 (0.541)                                              | -0.431 (0.528)                                                |                                                                |
| TCH_AGE      | Teacher age                                      |                   | 0.033 (0.022)                                               | -0.006 (0.026)                                                |                                                                |
| YEARS_M      | Total number of years teaching math              |                   |                                                              | 0.070** (0.033)                                               |                                                                |

Observations Used: 95  95  93  89
R-Sq: 0.4305  0.4308  0.4475  0.5161
Adj R-Sq: 0.4244  0.4120  0.4157  0.4807
F Value: 70.30  22.95  14.09  14.58

Standard errors in ( ).
*indicates significance at the 99% confidence level
**indicates significance at the 95% confidence level
INTRODUCTION

Numeric logic and reasoning skills obtained in the curricular sequence and content of K-12 mathematics programs have been a recent area of interest for education practitioners and policy-makers. Research has demonstrated links between basic numeracy concepts and post k-12 success in careers that require comprehension and application of numeric logic. A strong foundation in mathematics also leads to engaged preparation for and participation in the 21st century economy. Since this foundation is acquired and developed at the classroom level, the quality of the curriculum and the qualifications of the classroom instructor are of particular interest to education policy makers.

One program recently developed in accordance with research-based best practices in middle school math instruction is SimCalc, an experimental three-week computer-based unit that focuses on the pre-calculus essential skill of proportional reasoning, specifically the concepts of rate and slope. Motivated by SimCalc’s track record of success in individual classrooms in New Jersey and Massachusetts, SRI International, with a grant from the National Science Foundation, partnered with the project designers at University of Massachusetts at Dartmouth, as well as researchers at University of Texas at Austin and Virginia Polytechnic Institute to scale up the project into a four-year experiment in four school districts in Texas. The expressed hypothesis of the Scaling Up SimCalc Project is that “A wide variety of middle school teachers can use an innovative integration of technology and curriculum to create opportunities for their students to learn complex and conceptually difficult mathematics” (Shechtman 2006, p. 4).
The success of the SimCalc curriculum is directly linked to the teachers who will implement it. Indeed, “for policymakers and researchers looking for ways to improve K-12 education, one enduring approach has been to focus on teachers” (Wayne & Youngs 2003, p.89). Although the SimCalc approach to traditionally difficult subject matter is groundbreaking, the ability of classroom teachers to understand the material and transfer the knowledge to their students is essential. Because teacher demographic information such as race or gender and professional experience such as educational level or years teaching, as well as other background characteristics that existed prior to their exposure to the SimCalc curricula can potentially affect the teacher’s instructional efficacy, it is important to consider these characteristics in evaluating SimCalc. Awareness of the impact of teacher background on the implementation of the curriculum contributes to the larger understanding of the potential for SimCalc to revolutionize middle school mathematics by making foundational mathematical skills accessible to all students.

**BACKGROUND**

The links between student achievement and process-oriented standards, curricula, and classroom lessons have been heavily explored as focal points for education reform. Research confirms that effective lessons involve “simultaneous innovation in software, curricula, pedagogy, teacher training, and assessment” (Roschelle 1997, p.7). SimCalc, the teaching tool that is explored in this thesis project, was designed to help develop middle school students’ mathematical proficiency with the important concept of rate of change by combining a unique curricular approach with available technology. The
SimCalc MathWorlds software that accompanies the SimCalc unit is based upon the theory of a student-centered teaching methodology that resonates with students’ physical experience and linguistic abilities (Kaput 2002).

Education policy makers consider the relationship between the classroom teacher and student achievement important. In high stakes education policy and reform, analysts seek the areas of the K-12 system which provide the greatest opportunity for student achievement gains. Repeatedly, the qualities and qualifications of the classroom teacher demonstrate immediate and tangible impact, which potentially have real leverage in accomplishing long-term, widespread improvements to the education system. In 1973, at the annual symposium of the American Educational Research Association, W. James Popham introduced the notion of a ‘performance test’ paradigm for classroom teachers that reviews teacher success rates in terms of pupil achievement (Thorton 1977). His early framework laid the foundation for linking student achievement to teacher effectiveness in education research and policy reforms.

SimCalc’s instructional tools represent a conglomeration of pedagogical theories put into practice. The Scaling Up SimCalc Project is unique because it recognizes the importance of measuring both the degree to which the curriculum can be taught to the teachers as well as the effectiveness of the material in terms of advancing student achievement. The Scaling Up SimCalc Project involves a week-long training for teachers prior to the implementation of the curriculum in their classrooms.
LITERATURE REVIEW

Teacher Background Effect on Student Achievement

Many studies examine teacher background as an indicator for the teacher’s potential to transfer knowledge effectively and efficiently to the students in their classrooms. Collectively, these studies offer insight into the relationship between teacher and student and highlight characteristics of effective teachers.

In their survey of studies that analyze the relationship between teacher characteristics and test scores, Wayne and Youngs assert that research connecting specific teacher characteristics to student achievement is particularly relevant to education policy and practice because states and school districts specify teacher requirements in the areas of degrees, coursework and test scores (Wayne & Youngs 2003). They theorized that demonstrating a relationship between teacher characteristics and student outcomes is necessary to validate existing policies or to propose new policies in teacher hiring processes.

A comparable study in Tennessee looks at the relationship between teacher background and student achievement from the perspective of a state. Policy makers in Tennessee designed an evaluation tool to focus specifically on the value added of teachers. The tool generates a numerical estimate of teacher effectiveness and connects this in meaningful ways to student ability and socioeconomic background (Kupermintz 2003). Although the tool is not finalized and the findings are inconclusive at this point, the theory underlying its design points to a relationship between educational accountability and personnel decisions for hiring teachers at the state and district level.

4
The majority of studies conclude that there is a relationship between teacher background characteristics and student achievement but are reluctant to make blanket statements about which particular characteristics are universally effective. Concerns include the possibility of construct weights varying over time or across grade levels (Lockwood et al, 2007). Also, differences between teachers or students that correlate with the scores on assessment tests have not been systematically addressed in many existing evaluations (Kupermintz 2003). A final concern is that concepts of effective teaching change over time, and measurements of student achievement also change (Wayne & Youngs 2003). For example, in the 1980s, the instructional emphasis was on process-product teaching whereas present-day priorities emphasize subject area integration and putting the material in context (Wayne & Youngs 2003). This complicates any comparative analysis of studies on teacher’s background and their teaching effectiveness over time.

One body of research focuses specifically on teacher characteristics and their influence in math classrooms in particular. However, most of these studies focus on characteristics related to the teaching style rather than background characteristics. For example, categories that capture teaching style such as ‘clarity’, ‘questioning’, and ‘involvement’ are strong correlates of student achievement (Thornton 1977), but they do not reflect permanent characteristics such as race, age, or gender or semi-permanent characteristics such as years teaching or education level. A RAND study found that a teacher’s number of years of teaching was directly correlated with student test scores in fourth grade math classrooms in California (Klein et al 2001). This same study also
revealed that although there was not a direct correlation, “the pattern of coefficients lend some support to the hypothesis that white and other students score higher when they have teachers whose racial/ethnic group is the same as their own” (Klein et al 2001, p.8). Although the number of studies is limited, the research that focuses on math classrooms specifically concludes that generally “there is an indication that regular, planned school experience in conjunction with the mathematics preparation … may have an impact on teacher competency to produce mathematical learning in children” (Thornton 1977, p.24).

**Theory and Design of SimCalc**

Originally, SimCalc was designed in response to the concern that students in the United States are not as mathematically proficient as their global peers. Middle school mathematics sequencing and curricula content were targeted as the points where the gap begins because students at that level “are less likely to be taught or to master complex and conceptually difficult mathematics” (Shechtman et al 2005, p.3). This early disadvantage is compounded when students reach high school and have to apply complex mathematics concepts. A component of effective mathematics instruction identified by the designers of SimCalc was technology because of its potential to “create new opportunities for more students to develop deeper knowledge” (Shechtman et al 2005, p.3) of mathematics. The SimCalc researchers narrowed their focus to the concept of proportionality because it is a “central, crosscutting theme that involves number and operations, geometry and algebra, and connections among them and is a large focus area
in both the National Council of Teachers of Mathematics and state standards” (Shechtman et al 2005, p.5).

The SimCalc product that emerged from the research is a series of lesson plans that integrate software to help students understand proportional reasoning through interactive applications. Specifically, the software actively simulates linear motion through use of moving objects, and provides the associated position and velocity graphs, and tables and formulas. In this way, students engage high-level math problems, and through the computer images are able to make meaningful connections, which contribute to their understanding of the concept of rate of change (Shechtman et al 2005). SimCalc’s unique approach to teaching proportional reasoning through interactive applications helps students both access and retain the material. SimCalc also facilitates comprehension of more advanced topics in mathematics covered in subsequent math classes by cultivating a strong foundation at the middle school level.

The Relationship Between SimCalc and Teacher Background

The stated purpose of the Scaling Up SimCalc study is to “investigate if teachers from across the state of Texas can use a specially designed replacement unit [for the proportion segment of their curriculum] and the SimCalc software to help their students learn mathematics important to the Texas state frameworks as well as content that goes beyond the state framework—the beginning pieces of the mathematics of change leading to Calculus” (Schechtman et al 2006, p.15). The SimCalc project deliberately includes teachers in the stated hypothesis of SimCalc’s effectiveness. In addition, of the five
components of the SimCalc intervention, two are directly connected to teacher preparation and readiness: 1) a three-part training, including a summer and fall session, and 2) a replacement unit that addresses state standards and content in an easy-to-use form for teachers (Schechtman et al. 2006).

Although student achievement is the outcome of interest in the research design of the Scaling Up SimCalc Project revolves around teachers. The researchers distributed a survey to the teacher participants in the study and collected information on teacher background as key independent variables in the experiment. They also controlled for specific mathematical knowledge areas by providing additional training for the teachers randomly selected to use SimCalc and giving pre- and post-training content area tests to those teachers. Although my analysis looks only at the pre-existing teacher characteristic variables, and not the variables related to the SimCalc training, it is important to note that the larger SimCalc project places high value on teacher contribution to student achievement.

**Conceptual Framework**

*Hypothesis*

This analysis tests the hypothesis that teacher background has an effect on student achievement as measured through student test score gains in participating classrooms (both the control group and the treatment group) in year one of the Scaling Up SimCalc project.
Conceptual Model

The relevant teacher characteristics that could potentially impact student achievement as demonstrated in score improvement from pre-test to post-test upon completion of the SimCalc curricular unit are ones that align with the teacher’s ability to do the work as well as their ability to transfer this knowledge to the students in the classroom. Beyond teacher characteristics, other factors that could affect the pre-test to post-test achievement gains of the students include the demographic information of the school and background characteristics of the individual students. For example, if a school has always had high test scores historically or has students from middle or upper class neighborhoods, then test score gains could be attributed to external demographic factors. If the school has lower-achieving students from low-income background, then the failure of schools to achieve test gains could also be attributed to other factors. Also, innate cognitive ability, as well as race, gender, and age of the students themselves will contribute to the achievement of the students in all classrooms, including those using the SimCalc curriculum. Possible relationships between the dependent variable of interest and other key factors that theoretically contribute to student academic performance have been displayed in the diagram and specification that follows.
CONCEPTUAL MODEL:

- student achievement = f (teacher achievement, teacher background, school demographics, student background)

DATA AND METHODS

Data Source

The dataset, called Scaling Up SimCalc Year One, was collected through the Scaling Up SimCalc Project by researchers at SRI International in collaboration with Virginia Polytechnic Institute and State University, University of Massachusetts, Dartmouth, University of Texas at Austin and its affiliate, the Charles A. Dana Center. The Scaling Up SimCalc Project is a four-year endeavor which is currently in its third
year and is funded through a grant from the National Science Foundation. This analysis uses data from year one of the project collected during the 2005-6 academic year.

The project is a longitudinal randomized experiment that uses a delayed treatment design in which the participating teachers are randomly assigned to either the treatment group or the control group. In order to ensure equity, the control group in the first year receives the treatment the following year. Participating teachers were chosen from a voluntary applicant pool that was advertised in eight regions of Texas. Originally, 120 teachers from the applicant pool attended the initial teacher training. However, at the point in time when the experimental SimCalc curricula was implemented, only 95 teachers and their 1,621 students were still participating, and the data were only collected from those classrooms.

The data on teacher background was captured on a self-reported survey and the data on student test score gains was captured on pre-and post-tests administered prior to the implementation of the SimCalc unit and immediately upon completion of the unit, respectively. The data covers the following populations considered important and relevant to the project design: students, teachers, schools, and curricula content. The data subset used in this project includes an aggregate of students test scores, as well as background characteristics of the participating teachers.

*Analysis Plan*

This project analyzes teacher participants in the Scaling Up SimCalc experiment, focusing on the impact of teacher background on student achievement in both the
treatment and control classrooms. The dependent variable is student achievement as measured through test score gains. Key independent variables include teacher demographic characteristics, collected through records available through the schools and self-reported through surveys distributed by the researchers. The specific teacher characteristics that theory suggests might influence achievement gains and are included in the models are gender, total years of teaching math, ethnicity, age, and highest degree earned. As the data were obtained in a randomized experiment, the specific models for this analysis include a simple regression with only the treatment group variable and multiple regressions that include teacher background variables to determine whether or not the teacher characteristics have an additional effect on the student test score gains through the use of the SimCalc treatment.

Because the dependent variable is a continuous variable with a normal distribution, this analysis uses ordinary least squares as the regression model. The proposed specifications are:

- **Model 1:** \( Sa_{dif} = \beta_0 + \beta_1 \text{(newgroup)} + e \)

  Specification 1 is a simple linear regression model that tests whether or not the treatment significantly impacts student test scores.

- **Model 2:** \( Sa_{dif} = \beta_0 + \beta_1 \text{(newgroup)} + \beta_2 \text{(new\_tch\_gend)} + \beta_3 \text{(Hispanicnew)} + e \)

  Specification 2 is a multiple linear regression model that tests whether or not inherent teacher characteristics that cannot be altered and do not vary over time, such as race
or gender, have a statistically significant effect on student test scores, holding all other factors constant.

- **Model 3**: \( \text{Sa}_\text{dif} = \beta_0 + \beta_1 (\text{newgroup}) + \beta_2(\text{new\_tch\_gend}) + \beta_3(\text{Hispanicnew}) + \beta_4(\text{newdegree}) + \beta_5(\text{tch\_age}) + e \)

Specification 3 is a multiple linear regression model with added variables to test whether or not inherent teacher characteristics that can or do vary over time, such as education level or age, have a statistically significant effect on student test scores, holding all other factors constant.

- **Model 4**: \( \text{Sa}_\text{dif} = \beta_0 + \beta_1 (\text{newgroup}) + \beta_2(\text{new\_tch\_gend}) + \beta_3(\text{Hispanicnew}) + \beta_4(\text{newdegree}) + \beta_5(\text{tch\_age}) + \beta_6(\text{years\_m}) + e \)

Specification 4 is a multiple linear regression model with added variable that tests whether or not teaching experience in teaching math specifically, has a statistically significant effect on student test scores, holding all other factors constant.

**Variables**

**Dependent variable**

- **Student total gain (\( \text{sa}\_\text{dif} \))**: This is a continuous variable that reflects the total gain between the pre- and the post-tests administered through the SimCalc project. This is the variable of interest to the larger study because it serves as a proxy for the effectiveness of the SimCalc curriculum as compared to the regular curriculum. This is a variable of interest to this analysis because it captures the
effect of teacher background characteristics on the success of the implementation of the SimCalc curriculum.

**Independent variables**

- **Experimental group** (*newgroup*): This is a dummy variable for program participation, where 1= treatment group and 0=control group. Inclusion of this variable is critical to the model, as it defines the two subsets of the experiment. Theory predicts that participation in the treatment will result in gains in test scores.

- **Teacher gender** (*new_tch_gend*): This is a dummy variable that describes the gender of the teacher participating in the SimCalc program, where 1=female and 0=male. Inclusion of this variable is important to the model, as gender is a key background demographic. Theory does not predict whether either male or female teachers will be more effective in accomplishing student achievement gains through the implementation of a new curricular unit.

- **Years teaching math** (*years_m*): This is a continuous variable that reflects the total number of years teaching the math subject area of the participating teachers in the SimCalc program. Theory predicts that teachers with more years of teaching the math subject area will have higher test score gains among their students as a result of their familiarity with the specific subject.

- **Highest degree** (*newdegree*): This is a dummy variable that describes the educational level of the participating teachers, where 0=Bachelor’s degree and
1=Master’s degree (note: there were no PhD level participants in the program, which is why this is a binary variable). Theory predicts that the teachers with higher education levels have better training and will implement the SimCalc curriculum more effectively; hence, their students will have higher test score gains.

- Teacher ethnicity (
  Hispanicnew): This is a dummy variable that describes the ethnicity of the participating teachers, where 1=Hispanic and 0=Non-Hispanic. In general, theory does not predict which ethnic background will be more effective in accomplishing student achievement gains through the implementation of a new curricular unit. However, since the majority of the students in the Texas school districts where this project was implemented are Hispanic, the teachers who are also Hispanic might have a comparative advantage in relating to their students, and as a result, might have better test results in their classrooms.

- Teacher age (tch_age): This is a continuous variable that describes the age of the teachers participating in the study. This variable is important to predicting the dependent variable because knowing if the teacher’s age impacts their ability to successfully implement the SimCalc curricula is important in the larger applicability of the project results. Theory predicts that older teachers will be more experienced and will implement the SimCalc unit with greater success than younger teachers.
Table 1 and Table 2 show the demographic composition of the teachers in the Scaling Up SimCalc Year One dataset. The dataset included a total of 95 valid responses. The treatment and control groups are evenly split, with 51-percent of the sample in the treatment group and 49-percent in the control group. It is important to note that the background information on the project indicates that the average class size for both the treatment group and the control group were almost identical, with the teachers in the control group teaching an average of 17.5 students and the teachers in the treatment group teaching an average of 16.6 students. The demographic variables of teacher age, student achievement gain, group, and gender had a 100-percent response rate.

The mean age of teacher participants is 43 years, the minimum age is 25 years, the maximum age is 68 years, and the standard deviation is 9.9 years. 79-percent of the teacher participants in the sample are women, and 80-percent of the teacher participants held a bachelor’s degree with the remaining 20-percent of the teacher participants possessing a Master’s degree. The original variable on race was recalculated to determine the identification of ethnicity as it pertains to Hispanic or Latino origin, and it was observed that 77-percent of the participating teachers in the sample are non-Hispanic whites. The large percentage of White participants was surprising given national data of racial identification. However, both the distribution of the race and the gender variables were relatively consistent with teacher demographic information on teachers in the state of Texas, in which 73-percent are female and 71-percent are Non-hispanic whites. Also, the average age of the teacher participant in the SimCalc project (mean=43) was
practically identical to the average age of middle school Mathematics teachers in Texas, which is 42.4 (Tatar, et al 2007).

The mean number of years teaching math was 10.3 years, the minimum number of years teaching math was 1 year and the maximum number of years teaching math was 40 years, which suggests that the dataset contains some outlying values for number of years teaching math. The standard deviation is 7.8 years, which further suggests that there is a wide distribution of number of years teaching math among the teacher participants in the study.

Table 3 compares the distribution of background characteristics across the treatment and control groups. The differences in the breakdown of men/women, Hispanic/non-Hispanic, and Bachelor’s/Master’s were minimal, as in both groups, gender, ethnicity and education level were all within five percentage points of the other. Table 4 compares the means of the background characteristics across the treatment and control groups. It is interesting to note that the teachers in the treatment group had slightly higher averages in total years teaching math as compared to the teachers in the control group. In the control group, the average number of years teaching math was 9.5 years. In the treatment group, the average number of years teaching math was 11.04. However, the additional year in teaching math on average in the treatment group is partially explained by the higher average age of the teacher participant in the treatment group. The average age of the teachers in the treatment group was 43.15 years and the average age of the teachers in the control group was 42.11. Overall, the treatment and the
control groups were comparable in the distribution of the teacher background characteristics.

Table 5 compares the distribution of scores that increased the most (the upper quartile of test score improvements) to the distribution of scores that increased the least within both the treatment and the control groups. The upper quartile was bounded by a test score increase of 6.0 points or greater and the bottom quartile was bounded by a test score increase of 2.06 points or fewer. 48.94-percent of the test score gain in both the upper or lower quartiles were in the lower quartile and from the control group. None of the teachers with students in the lower quartile were from the treatment group. However, of the teachers with students scoring in the upper quartile, 44.68-percent of them were from the treatment group, and only 6.38-percent of them were from the control group. This distribution is somewhat unusual because statistical methodology suggests that in a random assignment study, it is highly unlikely that none of the teachers in the treatment group would have a class that had a lower response to the curriculum, regardless of the strength of the material or teacher. It suggests that a closer examination of the instrument that measures the success of this curriculum is perhaps warranted to ensure that is free of bias.

**Regression Results**

Having ascertained that the teacher characteristics are evenly distributed within both the treatment and the control groups, use of multivariate analysis determines whether or not an association exists between student test score improvement and teacher
background characteristics. Unfortunately, due to the limitations of my access to the complete SimCalc MathWorlds Year One dataset, this analysis was not able to control for the student background characteristics or school level information, both of which are likely to affect student tests scores. However, the research question for consideration specifically focuses on the effect of teacher characteristics on test scores, and the four models in my analysis were structured around the student test score gain variable and the categorical differences within the five independent variables of teacher characteristics. Tables 6 through 9 display the regression results of the individual models and Table 10 compares the coefficients and standard errors of the four regressions.

- **Model 1**: \( Sa_{dif} = \beta_0 + \beta_1 (newgroup) + e \)

  Model 1 is a simple model used to show the total effect of the SimCalc treatment on student test score increase. With \( t\)-value=8.18 (\( p<0.0001 \)), the coefficient on the treatment group variable is highly statistically significant at all conventional significance levels. Table 6 shows that on average, the student test scores of teachers in the treatment group increase 3.41 percentage points more than the student test scores of teachers in the control group. Intuitively, this makes sense, as the treatment group is exposed to the new curriculum, which has been designed to be more effective than existing curricula. Also, since theory predicts that student test scores are closely tied to student background characteristics, the 3.41 point difference in the increase in test scores between those students placed in the treatment group and those placed in the control group is relatively substantial.
The adjusted $R^2$ is 0.4244, which reveals that 42% of the variation in student test scores can be explained by the variation in the assigned group. This is a modest amount of the variation, which tells us that our empirical specification (our model) is accurate, but that there are other factors that affect the variation in student test score.

- **Model 2:** $S_{a \_dif} = \beta_0 + \beta_1 (new\_group) + \beta_2(new\_tch\_gend) + \beta_3(Hispanicnew) + e$

Model 2 is a multiple linear regression model that adds additional explanatory variables of race and gender to Model 1 to test whether or not innate teacher characteristics that cannot be altered and do not vary over time have a statistically significant effect on student test scores, holding all other factors constant. With t-value=8.25 ($p<0.0001$), the coefficient on the treatment group variable is highly statistically significant at all conventional significance levels, holding all other factors constant. Table 7 shows that on average, the student test scores of teachers in the treatment group increase 3.40 points more than the student test scores of teachers in the control group. Again, this conforms to the intuition that exposure to the new curriculum will result in higher test scores. However, the added teacher characteristics of race ($p=0.8631$) and gender ($p=0.8971$), the variables of interest in this model, are not statistically significant at any conventional significance levels, holding other factors constant.

The adjusted $R^2$ is 0.4120. This reveals that 41% of the variation in student test scores can be explained by the variation in the assigned group and the variation in teacher gender and the variation in whether or not the teacher self-identifies as Hispanic.
Model 3: \( Sa_{\text{dif}} = \beta_0 + \beta_1(\text{newgroup}) + \beta_2(\text{new\_tch\_gend}) + \beta_3(\text{Hispanic\_new}) + \beta_4(\text{new\_degree}) + \beta_5(\text{tch\_age}) + e \)

Model 3 is a multiple linear regression model that adds additional explanatory variables of educational level and age of teacher to Model 2 to test whether or not teacher characteristics that can or do vary over time have a statistically significant effect on student test scores, holding all other factors constant. With t-value=8.14 (p<0.0001), the coefficient on the assigned group variable is again highly statistically significant at all conventional significance levels. Table 8 shows that on average, the student test scores of teachers in the treatment group increase 3.39 percentage points more than the student test scores of teachers in the control group, holding other factors constant. However, the added background characteristics of education level (p=0.2124) and age (p=0.1440), the variables of interest in this model, are not statistically significant at any conventional significance levels, holding other factors constant. As they are not statistically significant, it is not appropriate to interpret their coefficients, but it is important to point out that compared to the innate teacher characteristics of race and gender, the teacher characteristics that do change over time have a higher t-value, which suggests that they are more likely to affect student test scores than the characteristics that do not change.

The adjusted \( R^2 \) is 0.4157. This reveals that 42% of the variation in student test scores can be explained by the variation in the assigned group, the variation in teacher gender, the variation in whether or not the teacher self-identifies as Hispanic, the variation in age and the variation in education level.
Model 4: \[ Sa_{dif} = \beta_0 + \beta_1 (new\_group) + \beta_2(new\_tch\_gend) + \beta_3(Hispanicnew) + \beta_4(new\_degree) + \beta_5(tch\_age) + \beta_6(years\_m) + e \]

Model 4 is a fully-specified multiple linear regression model that adds the additional explanatory variable of total number of years teaching math to Model 3 to test whether or not the teacher characteristic that speaks to the teacher’s professional experience specifically in the math subject-area has a statistically significant effect on student test scores, holding all other factors constant. With t-value=8.55 (p<0.0001), the coefficient on the assigned group variable is again highly statistically significant at all conventional significance levels. Table 9 shows that on average, the student test scores of teachers in the treatment group increase 3.47 percentage points more than the student test scores of teachers in the control group, holding other factors constant. Additionally, with a t-value of 2.14, the added teacher characteristics of years teaching math (p=0.0357), the variable of interest in this model is statistically significant at the 95% significance level, holding other factors constant. For every additional year of teaching experience in the math subject area, the student test score gains increase by .07 percentage points. This is both a substantively and statistically sizeable amount of increase, and implies that teaching experience in the math subject area plays an important role in the successfully implementation of the SimCalc curricula.

The adjusted \( R^2 \) is 0.4807. This reveals that 48% of the variation in student test scores can be explained by the variation in the assigned group, the variation in teacher gender, the variation in whether or not the teacher self-identifies as Hispanic, the
variation in age, the variation in education level, and the variation of number of years teaching math.

Comparatively, the four models had increasing degrees of explanatory power as evidenced by the gradual increase in the adjusted R². However, given the lack of statistical significance of the majority of additional variables, it is more plausible to understand much of this increase as “noise” resulting from the addition of new variables (see Table 10). All four models showed consistent results that while placement in the treatment group had a statistically significant and positive effect on student test score gains, the majority of teacher background characteristics had no statistically significant effect on test score gains. The exception to this finding was the variable that captures the effect of years teaching math, as the professional experience providing classroom instruction in math in particular positively impacts the implementation of the SimCalc curricula. However, the lack of significance in the other variables strongly suggests that with the exception of experience teaching math, teacher background characteristics have an uncertain and limited impact on increased student achievement as captured by gains in test scores produced by the SimCalc curriculum.

LIMITATIONS OF THE DATA

The primary limitation of the dataset is that the analysis is conducted at the classroom level so that there are only 95 observations. Although the project looks at teacher background variables, the small number of observations restricts the number of variables that could be included in the model according to econometric methodology.
This sample size also weakens the internal validity of this analysis, as a small sample could result in the causal effects being estimated imprecisely. Another limitation of the dataset used in this analysis is that it does not include information about the original 120 teachers who signed up for the project. However, in the technical report compiled at the end of year one of the project, SRI researchers noted that there is no evidence that would suggest differential attrition and thus compromise the validity of the study. A final limitation is the threat to the external validity of the study, since there is a possibility that because the teachers in the dataset teach in middle schools in Texas, they are a non-representative sample of the larger population of teachers in the United States. Hence, it might not be appropriate to generalize findings to the national cohort of middle school mathematics teachers because this study was limited to a single state.

**Policy Implications**

The results suggest that the SimCalc curriculum can be used effectively by a variety of mathematics teachers. This supports policy efforts that seek to identify and encourage implementation of curricula that will improve student achievement in middle school math classrooms.

In order to stay competitive in a globalizing economy, the United States often turns to the education system to train the workforce for the future. Yet despite increased budgets and spending on education and local and national political pressure on public school systems, skill levels, particularly in the math and science subject areas, continue to lag behind other countries. As newsman and political commentator Jim Holt notes, “In
the United States, mathematics education is often felt to be in a state of crisis. The math
skills of American children fare poorly in comparison with those of their peers in
countries like Singapore, South Korea and Japan” (Holt 2008, p.43). Also, numeracy
skills as measured by standardized tests tend to be lower for low-income and minority
students as compared to upper-income or white students. Policymakers and political
leaders encourage education reforms with proven track records of success because these
programs potentially offer large return on educational investment. If the SimCalc
curriculum is effective in all classrooms and can be used by a range of teachers, then it
can be a powerful tool for reducing the achievement gap in middle school math
classrooms. Further, it could position students in middle school to capitalize on the
momentum established by their early academic successes and pursue careers in science
and technology, thus improving the competitive standing of the United States workforce
and elevating the United States’ position within the global economy.

The lack of significant results for four of the teacher characteristics included in
the analysis validates any larger application of the SimCalc curriculum, as a wide variety
of teachers can use the curricula effectively. The significance of both the variable
measuring the impact of years teaching math and the variable measuring the impact of the
SimCalc curriculum specifically further confirms the usefulness of SimCalc, as it implies
both that the curricula is effective, and that this effectiveness is compounded when used
by math teachers with professional experience. These findings support curricula and
content standards policies that enable schools to replace the existing units on rates and
proportion with the SimCalc curricula and human resource policy that encourages middle
schools to hire math teachers with experience teaching the subject matter. The SimCalc intervention is designed to teach students critical mathematics skills which will facilitate their immediate success in middle school mathematics and holds potential for ensuring future success in high school and college-level mathematics and sciences. Since the majority of teacher characteristics do not affect student achievement through the application of the SimCalc curriculum, this tool can positively impact student achievement in the acquisition of pre-Calculus skills in middle school math classrooms. If legislators value the education system as a vehicle for improving the US position in the global market, then endorsing the SimCalc curricula with its proven success with student achievement and ease of use for teachers is highly recommended.

CONCLUSION

Research efforts and policy discussions have focused on raising student achievement, particularly in math. As an intervention at the middle school level, the SimCalc curriculum has the potential to have an immediate effect on strengthening proportional reasoning skills and a future effect on improving student achievement in calculus and higher level mathematics. However, in order to ensure success in all classrooms, designers of any new curricula must consider the critical role that teachers play in implementing the lesson plans and explaining the material. The conclusions reached in this analysis show that select teacher background characteristics have no significant effect on SimCalc’s impact on student achievement. Further, SimCalc’s capacity to be used by any teacher and used more effectively by experienced math teachers is an
important finding which should prove useful in justifying widespread use of the SimCalc curriculum.
REFERENCES


