# Making the Grade:  A System Dynamics Evaluation of No Child Left Behind

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**Abstract**

Many students in America are being left behind when it comes to education. Certain areas continually show poor standardized test scores and drop out rates. There are numerous reasons that students in these areas are unable to succeed. Poor economic health, inadequate schools, and distressed family lives are just a few of the reasons these students are having trouble.

Trying to help these students, the No Child Left Behind Act was enacted. The goal of this piece of legislation is to aid the students that are failing. To achieve this goal, No Child Left Behind focuses strongly on the accountability of schools. However, the No Child Left Behind Act has come with several unintended consequences. Student performance has not increased in many schools, and in several cases, student performance has decreased.

This thesis uses system dynamics methodology to explore why No Child Left Behind succeeds in some cases and why it fails in others. While some schools are thriving under this piece of legislation, others are falling even further behind. Many contributing factors are involved in the dynamics of this situation and the ability to understand these factors and their relationships are key in mitigating the situation.

This thesis describes a system dynamics model that can be used as a decision support tool for policymakers. This model examines the dynamics between funding, school infrastructure, demographics, and school performance over a 20 year period. This model helps to identify the key reasons No Child Left Behind succeeds or fails.

# Chapter 1: Introduction

## *Introduction*

Education is one of the main keys to success in this world. Education opens doors to places that may otherwise be closed. Everyone has the right to learn and be educated. Although everyone has this right, the quality and effectiveness of our educational system varies widely from area to area. Impoverished areas generally do not provide the same quality of education as more affluent areas. This fundamental aspect of society makes it difficult for those in poverty stricken areas to get ahead in life. As part of an effort to help close the gap between areas that receive quality education and those that receive less than quality education, the government created the No Child Left Behind Act (NCLB, 2001) in 2001. While this legislation was passed by an overwhelming majority, it has also had many detractors. Some school districts have flourished under No Child Left Behind, while other districts seem to have fallen into a sort of death spiral of declining achievement. This thesis provides a system dynamics study of two separate school districts to develop an understanding of the dynamic impact of No Child Left Behind in each district. One of the districts (Sacramento County) has experienced continued academic performance improvement since the institution of NCLB. The other district (Palm Springs Unified) has experienced an accelerating decline in academic performance.

These two districts have very similar demographic and economic characteristics. Both districts have a large Hispanic population that make up the largest ethnic group in each district. Palm Springs Unified is made up of 79.4 % minority students, while Sacramento City Unified is made up of 77.3 % minority students. They both have a large amount of students that receive free or reduced meals (a key indicator of economy of surrounding area). However, since the beginning of NCLB, the drop out rates, graduation rates, and school performance in these districts have moved in opposite directions and the gap is continuing to grow ever wider.

Drop out rates and graduation rates are two key indicators of how well a school district is preparing its students. The ability to retain students is extremely important for the future of the students and for the economic success of the community. Students who graduate are able to generate more income than those that drop out from school.

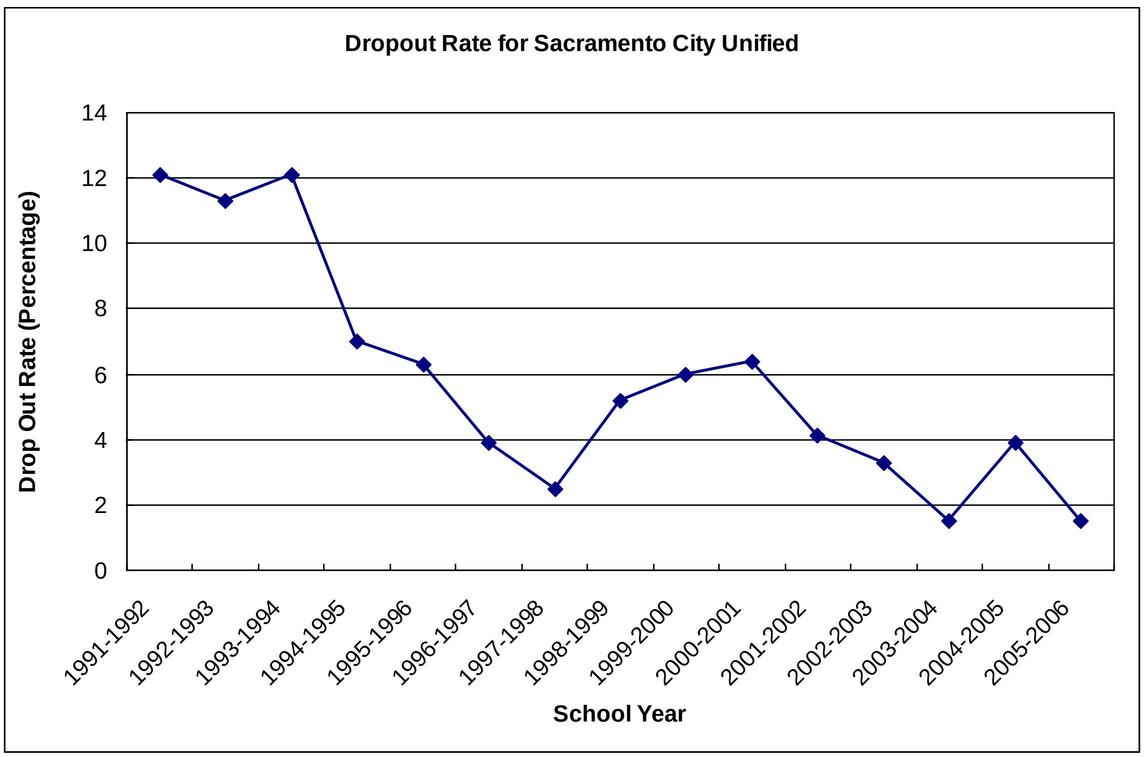


**Figure 1: Percentage of Sacramento City Unified Students who Drop Out Every Year (DataQuest, 2008)**

Over the last 25 years the drop out rate of Sacramento City Unified has shown a continuing decline (Figure 1). The drop out rate of Sacramento City Unified has dropped from 12.1 % to 1.8 % from the 1991-1992 school year to the 2005-2006 school year and from 6.4 % to 1.8 % from the 2000-2001 school year (beginning of NCLB) to the 2005-2006 school year.

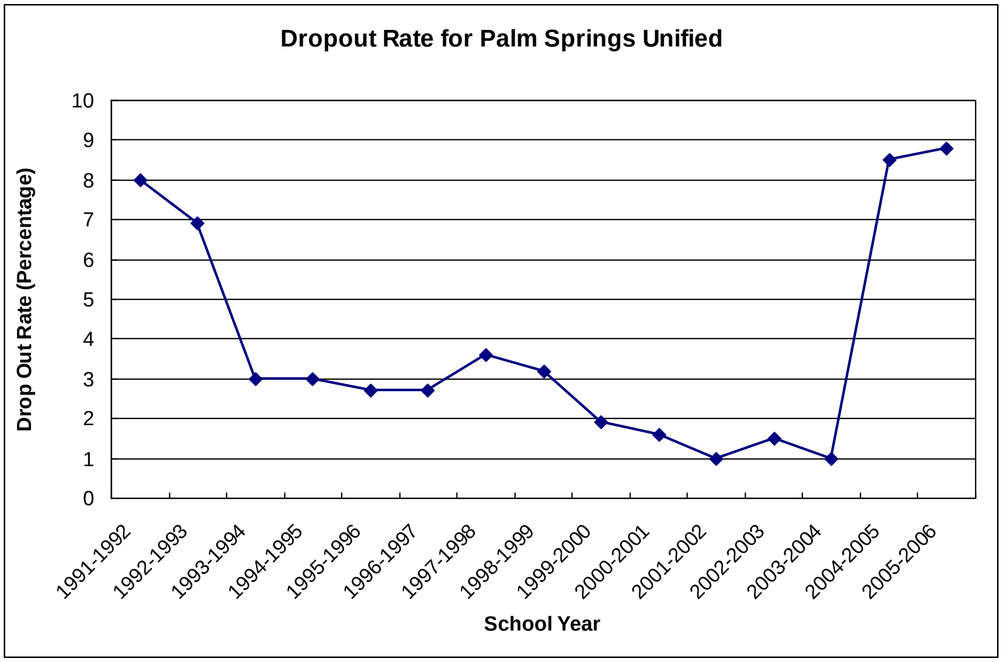


**Figure 2: Percentage of Palm Springs Unified Students who Drop Out Every Year (ibid)**

Conversely, Palm Springs Unified has just recently seen a large increase in drop outs (Figure 2). Although they saw a steady decline in drop out rates from the 1991-1992 school to the 2003-2004 school year, over the last couple of years the drop out rates have skyrocketed from 1.0 % to 6.8 %.

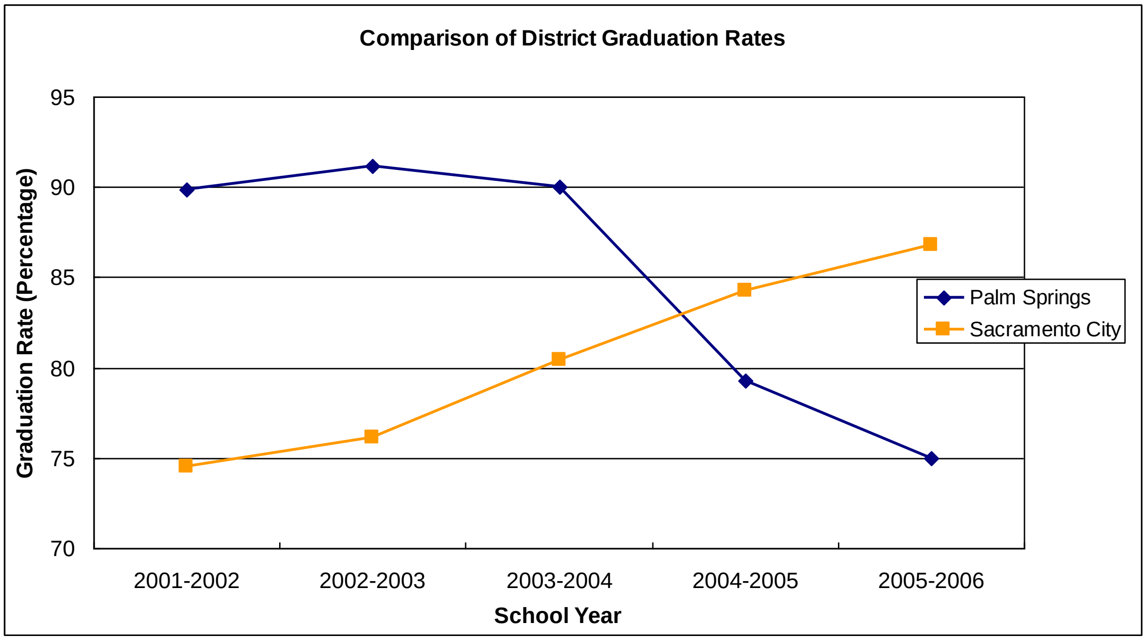


**Figure 3: Percentage of Seniors Graduating from Sacramento City and Palm Springs every year (ibid)**

The graduation rates for these two districts are heading in opposite directions (Figure 3). Palm Springs Unified began the 2001-2002 school year with an outstanding graduation rate of 90 %, while Sacramento City Unified's graduation rate in that year was slightly above the national average at 75%. Over the last few years, both school's fortunes have reversed. While Palm Springs Unified's graduation rate has dropped down to 75 %, Sacramento City Unified's has grown to 86 % and has steadily increased since 2001-2002.

The main indicator that will be used in this thesis to show whether a district is successful or not is the district's performance on standardized tests. California has had a standardized testing structure called Standardized Testing and Reporting (STAR) that has been in place since 1998. These standardized tests are used to gauge student performance in different areas of study. In the No Child Left Behind era, they are also used to make schools accountable for the quality of education that they are providing students. Districts that perform poorly on standardized tests are reprimanded while those that do well are rewarded. Figure 4 shows the standardized test scores over the last 5 years for both school districts.

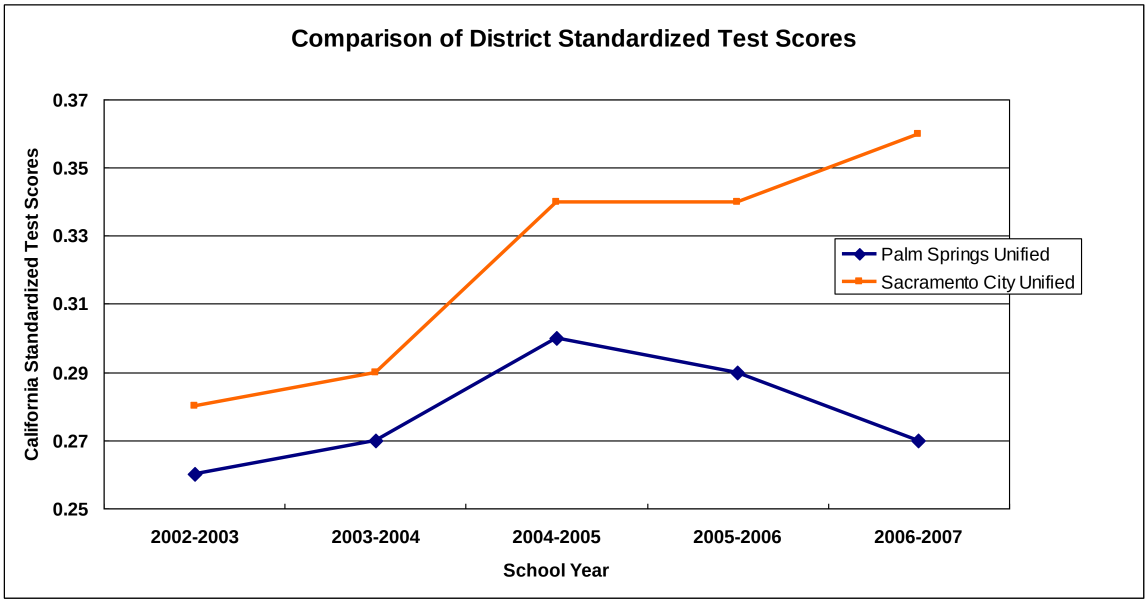


**Figure 4: Comparison of the STAR Test Scores for Palm Springs and Sacramento City over the past 5 years (ibid)**

These results show that Sacramento City Unified has exhibited continually improving performance while Palm Springs Unified's schools' performance is declining. These test results represent both the good and the bad of No Child Left Behind. Some schools are continuing to improve the performance of their schools, while others are falling behind. Both of these districts have a large percentage of schools marked for program improvement. Schools are put into program improvement when they fail to reach the goals set forth by No Child Left Behind. Under program improvement, money and resources are spent to try and get the schools up to the required standard, but program improvement only seems to be working for Sacramento City Unified. The number of schools in each district marked for program improvement can be seen in Table 1.

| | **Palm Springs Unified** | **Sacramento City Unified** |
|---|---|---|
| **Number of Schools** | 24 | 77 |
| **Number in Program Improvement** | 14 (58.3 %) | 30 (40.0) |
| **Number of High Schools** | 5 | 12 |
| **Number in Program Improvement** | 3 (60.0 %) | 5 (41.7 %) |

**Table 1: Comparison of the number of schools in each district that are marked for program improvement (ibid)**

The remainder of this chapter begins by explaining the dynamics giving rise to this behavior in Figure 4 by exploring the assumed dynamics underlying student performance that NCLB is intended to address. Then the chapter will explore the how the specific policies and implementation of No Child Left Behind could impact those dynamics. A discussion of current literature and studies that evaluate the impact of No Child Left Behind on student performance will follow. Finally, a description of how a system dynamics approach to understanding this problem adds to this ongoing conversation will be given.

The chapters following this one will include an overview of the system dynamics model created for this thesis. A detailed look at the relationships involved in the model and the results that arise from these relationships will be discussed. The next few chapters will discuss how this model was validated against real world statistics. This thesis will also describe the rationale behind the variables that are in the model. The results of the case studies and simulations of Sacramento City Unified and Palm Springs Unified will be discussed along with the results of other simulations that will be run through the model. Then this thesis will talk about the policy implications that follow with these results. A discussion on possible changes that could overcome some of the deficiencies in No Child Left Behind will be discussed. The thesis will end with the restrictions, assumptions, and future uses of the model and then final conclusive remarks about the study.

### *Purpose of this Research*

The main purpose of this research is to provide a tool to evaluate No Child Left Behind's impact on two separate school districts. A focus is on how school funding, school infrastructure, the impact of remedial programs, and demographics impact student achievement. This thesis will try to elucidate and model the dynamics explaining why some schools exhibit increasingly higher levels of performance under NCLB, while others exhibit ever poorer levels of performance. The goal is to create a simulation tool that can lead to deeper understandings of the problem and provide guidance to policymakers seeking to improve school performance.

No Child Left Behind has changed the way that schools are run. A deep understanding of the interplay between NCLB and the local schools policymakers will help to identify more effective ways to improve student performance. The goal of every school district is to create a sustainable quality educational setting that will help every student improve. This thesis should help supervisors and planners to more effectively pursue this goal.

*The Dynamics of School Achievement*

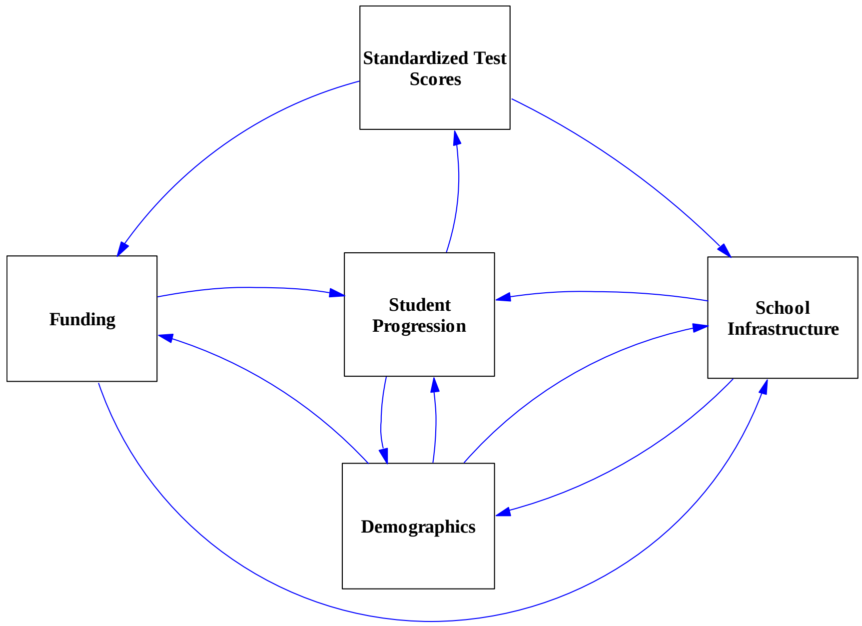


Figure 5: The Dynamics of School Achievement

Figure 5 illustrates the complex dynamics that are involved when looking at school achievement. Figure 5 shows how these sections (Funding, Demographics, Student Progression, School Infrastructure, and Standardized Test Scores) are all connected and how they all impact each other. The main section which will be analyzed is the Standardized Test Scores section which represents the overall performance level of students within a school. School achievement is not simply impacted by what occurs within a classroom. School infrastructure (physical facilities, teaching staff, etc), funding, and demographics (makeup of the student body and surrounding community) all play a major role in school achievement. These factors impact student achievement by affecting student progression within the schools. The following section will look at how student progression affects school achievement and also how school infrastructure, funding, and demographics impact school achievement by affecting student progression. A detailed look at the dynamic relationships among each of the elements will also be discussed. These elements are ever-changing due in part to their interactions with each other. The rest of this section will discuss these interactions and how they impact each other.

### Student Progression and Standardized Test Scores

Before looking at how the other elements impact achievement it is important to understand student progression and its relation to school achievement. Student progression refers to the movement of students from one grade to the other as well as the movement of students in and out of the school. It is made up of four different elements; student performance capability, drop-out rates, graduation rates, and grade advancement. These elements can be seen in Figure 6.

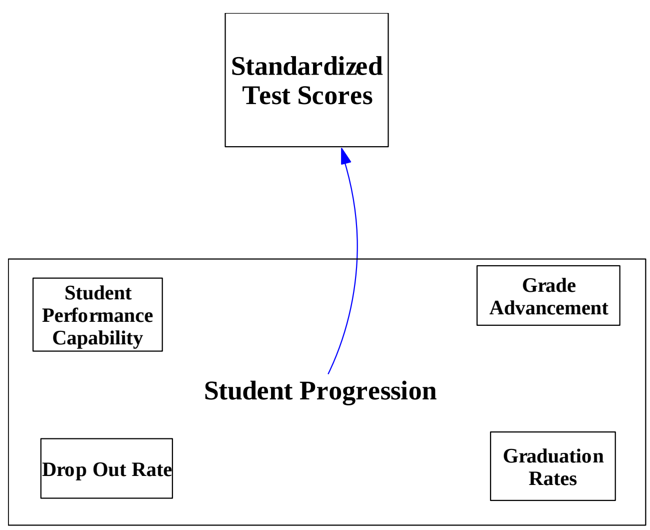


**Figure 6: Student Progression and its impact on Standardized Test Scores**

With relation to standardized test scores, student performance capability is the main element that will be looked at. The student performance capability is defined as the ratio of high risk students to low risk students. High risk individuals are those people who are at a higher risk to perform poorly on standardized tests. Conversely, low risk individuals are those that are expected to perform well on standardized tests. The number of high risk and low risk individuals is determined through certain demographic variables and the school infrastructure. The higher number of low risk students that are in the school, the higher the overall ability for students to pass the standardized tests will be. Students have the ability to progress from being a high risk individual or the ability to digress into being a high risk individual. Drop-out rates, graduation rates, and student advancement from grade to grade are all linked to the capability of a student to perform well on standardized tests. As this ability increases, the drop-out rate will decrease, the graduation rate will increase, and more students will advance to the next grade. Again, these elements are all firmly linked to the ability of students to perform on standardized tests. The rest of this section will look at some of the factors that affect standardized test scores.

**School Infrastructure and Standardized Test Scores**

The ability of a school to enhance achievement depends greatly upon the infrastructure that is built. Variables that impact school infrastructure quality are numerous and varied. These variables are used in the model that will be shown later in the paper. This section will look at the variables seen in Figure 7 and how they impact school achievement.

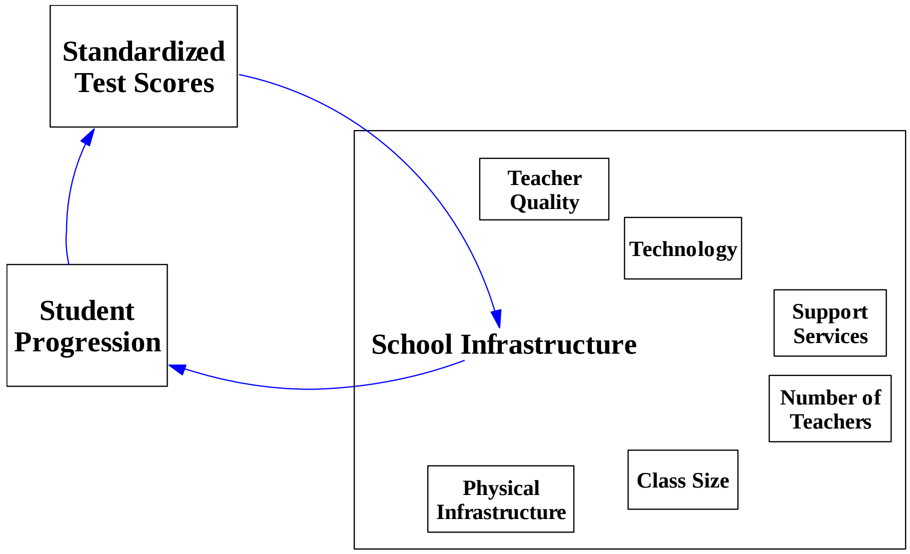


**Figure 7: Impact of School Infrastructure on Standardized Test Scores**

The quality of teachers in a school has a great impact on their ability to improve school achievement. Teachers that are able to properly communicate their lessons to their students help to increase the achievement level of their school. (Haycock and Crawford, 2001) Teacher quality can be measured by looking at a teacher's accreditation or past performance evaluations. At the school level, overall teacher quality can be measured by looking at the percentage of teachers who have achieved accreditation. Having a large percentage of teachers who are accredited within a school is an important factor in determining the quality of teaching that takes place within that school (Amrein-Beardsley, 2007). Attracting teachers of high quality is difficult, but essential in improving standardized test scores.

Class size is another important element in school infrastructure. Small class sizes allow teachers to provide more one on one attention to their students. Studies show that this type of attention is critical in student achievement (Haenn, 2002). Large class sizes deter a teacher from being able to communicate with students at an individual level. Large class sizes also make it much tougher on a teacher to handle poor behavior within a classroom, which can greatly detract from a student's ability to learn. Finally, in a larger class setting students are less likely to participate, which prevents the classroom from becoming an interactive experience (Finn, Gerber, and Boyd-Zaharias, 2005).

In school and out of school support services such as tutoring can help aid in improving achievement. Tutoring can be done in school or provided by an institution outside of school. Tutoring is a very effective tool, since it allows for the one on one interaction that students generally miss in the classroom. Effective tutoring is extremely helpful in reaching students who feel lost in larger classrooms. This aspect of school infrastructure will be considered to be its own element because of No Child Left Behind.

The 21st century classroom benefits greatly from having new technology. Computers, the internet, and educational video games are all technologies that help to enhance a student's learning environment. Technology allows students to learn in a different way than they may be used to. The internet permits students to augment their education by researching different areas of interest. Educational video games provide students with an entertaining and interactive way to improve test scores. Not all schools have the means to provide this type of technology to their students, but those that do, have a very effective way to improve school achievement (Jeffs, Behrmann, Bannan-Ritland, 2006).

One final school infrastructure variable that helps to improve achievement that should not be overlooked is the physical facilities in the school. A school that is run down and in need of great repair will greatly impair student achievement. When students look at a school that is run down they lose confidence in that school's ability to help them learn and in the school's desire to help them improve (Roberts, Edgerton, Peter, 2008). The deterioration of the physical infrastructure of a school can greatly lower a student's self-esteem and craving to learn. A well kept school is a great breeding ground for improving achievement, student performance, teacher morale, and retention.

The link between performance on standardized test scores and school infrastructure is important when discussing how to attract higher quality teachers into the school. Schools that have a long history of high performance will have a better chance of attracting quality teachers. Teachers will want to go to a school that is well run and that is filled with students who have a willingness to learn (Clodfelter, et al, 2004). The other infrastructure elements are affected by achievement through funding and will be discussed in greater detail when discussing the dynamics of No Child Left Behind.

**Funding and Standardized Test Scores**

In order to improve standardized test scores, money is a necessity. The best improvement plans can falter due to lack of funding. Schools receive money through a number of different routes as is seen Figure 8.

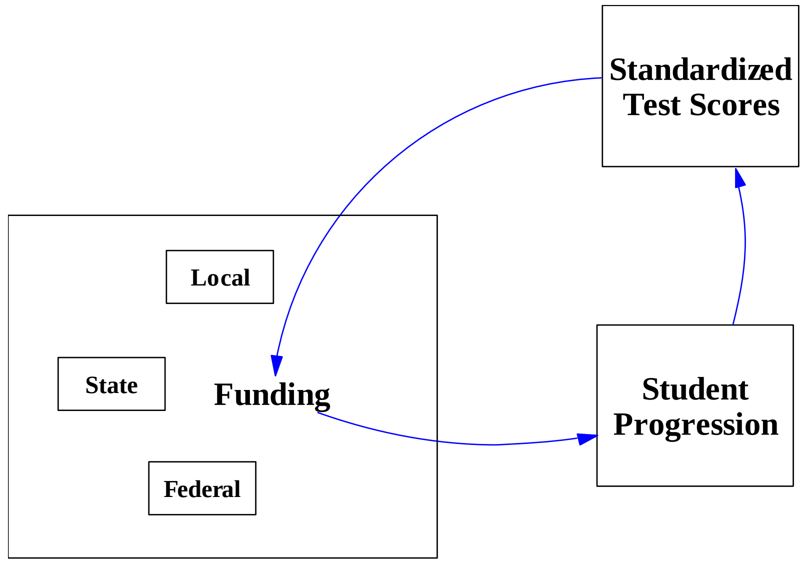


**Figure 8: Impact of Funding on Standardized Test Scores**

Schools receive money locally from taxes as well as from the lottery. They receive money from the federal government through federal grants that allocate funds for specific programs such as No Child Left Behind. Finally, a large amount of funding for education is provided by the state and through state programs. The impact of funding on performance is mostly seen through its impact on school infrastructure, but increased funding does send a message to students within the school that the government and administration have a stake and interest in how they perform. Also, the way the money is spent is an essential element in analyzing the success of funding programs.

Many schools receive money through government funding that depends upon student performance. This portion of the system will be explained in detail later when discussing No Child Left Behind and how standardized test scores impact the amount of funding and type of funding that a school receives.

## Demographics and Standardized Test Scores

Demographics refers to the general makeup of the community. Such things as the average income, age, and education level all make up the demographics of an area. The demographics of the area surrounding the school play an integral role in the achievement of that school. When it comes down to it, the performance of the school is rooted in the performance of its students as can be seen in Figure 9.

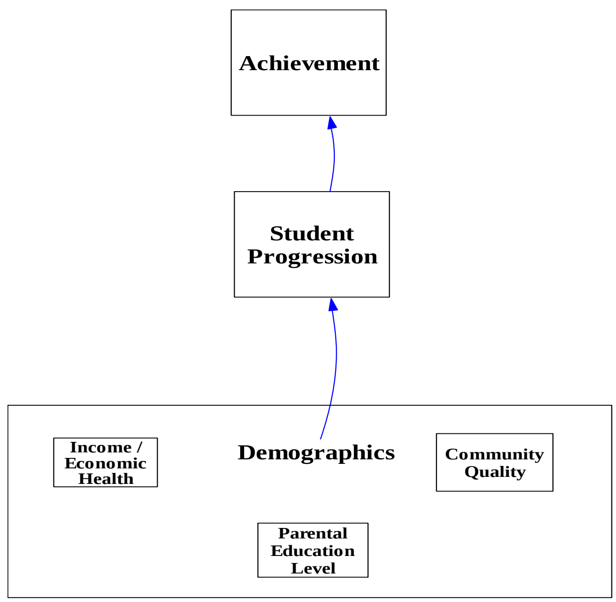


**Figure 9: Impact of Demographics on Standardized Test Scores**

Its students come from the surrounding community and are greatly impacted by that community. Many of the demographic variables that play into student achievement are linked together, but each of them needs to be analyzed in order to paint a picture of the social context in which the school operates. The main demographic variables that will be analyzed in this paper are economic health and parental education level. Economic health refers to the average income of a community which can also be a major indicator of school achievement. Studies show that those communities with a larger percentage of economic contributors or high income families have schools with a higher amount of achievement (Koop, 2008). Families with higher income levels also tend to have parents who have reached advanced levels of education, which is also a key indicator for student and school achievement (Hernandez, 2004). Students who have parents at home that are educated, generally, have a strong base of support in their academic endeavors. The makeup of the student's family also plays a key role in the development of school achievement. Students who come from two parent households perform better in school than those that come from one parent or no parent households (Nord, 1998). Again, having two parents creates a strong base of support for the student. Many times, single or no parent households put extra stresses on the students outside of school, distracting them from their academics. The overall community quality of the area is a representation of the quality of the schools, the economic health of the area, and the amount of criminal activity. The economic health of the area was discussed earlier and the quality of the schools is discussed within the school infrastructure portion. The crime rate of a particular area is the final factor that plays into community quality (Ferryman, et al, 2008). Higher crime rates generally reflect a neighborhood full of distractions and dangers. It is tough for a student to concentrate on academics when he has to worry about his safety or the temptation of drugs. This paper will not go into depth on the impact of crime rate on achievement. All of these variables can be linked together and connected in many different ways. A more detailed discussion on how these variables connect and interact with school achievement will be seen later on in this paper. This discussion will show how analyzing community demographics by themselves cannot fully predict school achievement.

## Student Progression and Demographics

The makeup of a school and its students is determined in large part by the demographics of the surrounding area. As was mentioned earlier, student performance is influenced highly by the income, parental education level, family makeup, and crime rate of the community that they come from. This can be seen in Figure 10.

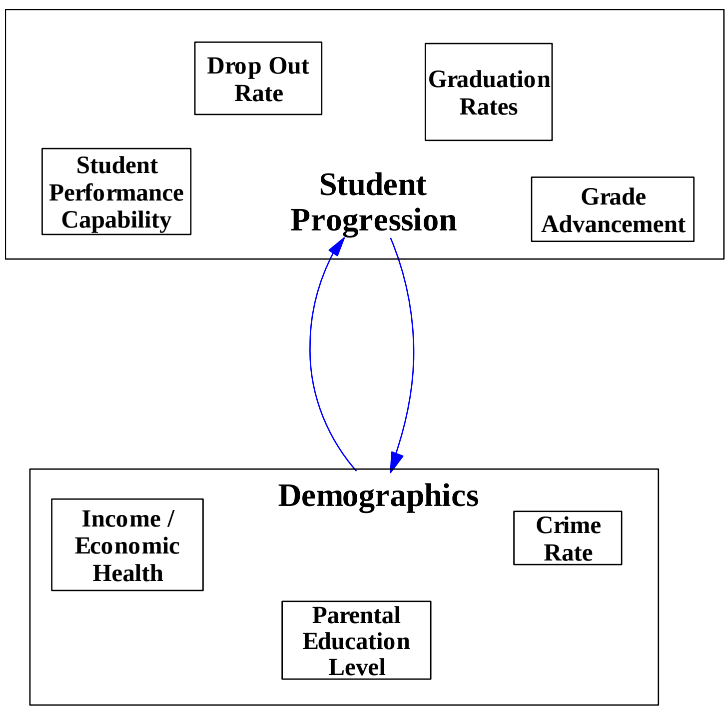


**Figure 10: Impact of Student Progression and Demographics on each other**

These demographic factors shape the type of student that enters into the school. Student progression also has a large impact on the demographics of the community. The income of the surrounding area is increased as the number of graduates increases. Individuals who graduate from high school have more spending power and more power to generate money inside the community. The parental education level is also improved since the more individuals that graduate, the more likely that the families will be made up of parents that are educated. The crime rate of an area is decreased if the number of graduates increases as the number of drop outs decreases. If a large number of individuals drop out of high school, they will more than likely become economic detractors within the community. The cyclical relationship of these two elements is an extremely important part of the dynamics of achievement.

### Funding and School Infrastructure

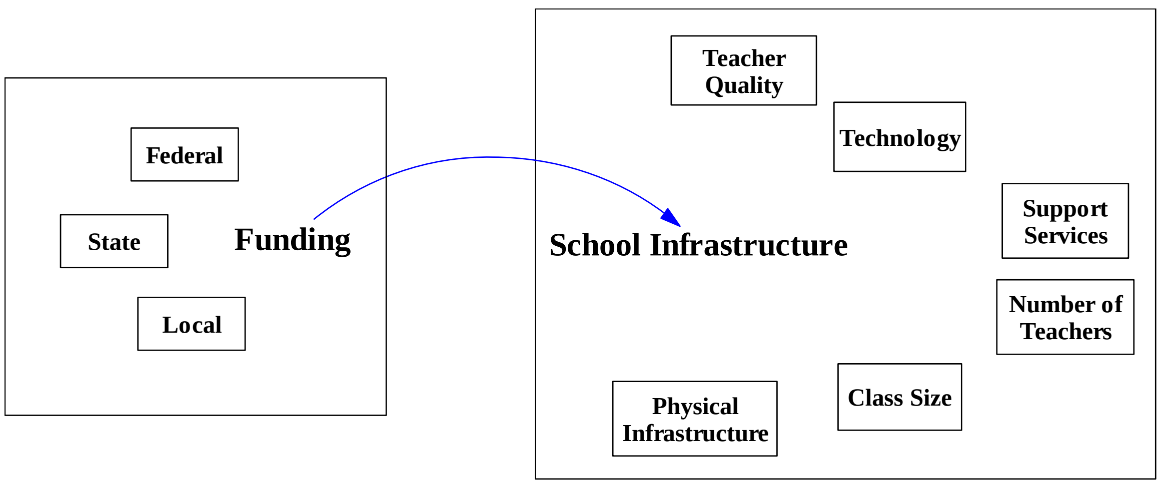


**Figure 11: Impact of Funding on School Infrastructure**

Figure 11 illustrates how funding impacts school infrastructure. As funding increases, schools can begin to bring in teachers of better quality. The possibility of higher salaries will draw in more highly qualified teachers, as will the possibility of working with a school that has money to spend on improving the facilities. Increased funding also brings about the possibility of bringing in more teachers, thereby decreasing class sizes. Extra funding also allows schools to pay for in school and out of school tutors, as well as more computers and other types of technology. Finally, extra funding allows for repairs and additions to be made to the physical infrastructure of the school. This could also mean more classrooms, which means smaller class sizes.

**Demographics and School Infrastructure**

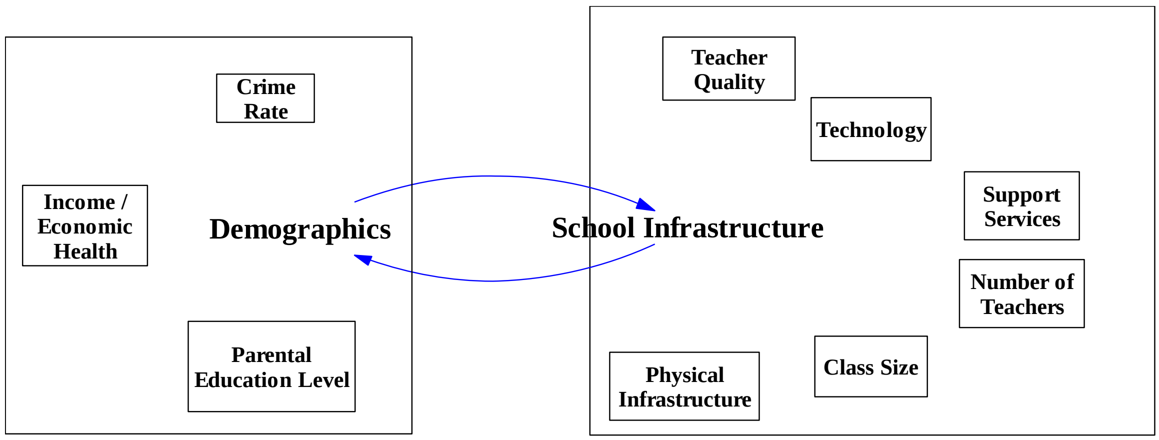


**Figure 12: Impact of Demographics and Infrastructure on each other**

Figure 12 shows a strong link between demographics and school infrastructure. This link demonstrates the importance of the community on the school and also the school on its surrounding community. The income and crime rate of an area have a lot to do with attracting teachers of quality and also the number of teachers. Teachers are more likely to go to a school that has a safe surrounding area. Crime rate also impacts the physical infrastructure because of the possibility of vandals. A school covered in graffiti would have a large impact on the students' and teachers' morale. Schools that bring in teachers of high quality will begin to bring in more and more individuals of higher income. The schools will begin to look more attractive to people looking to move into the area. The same could be said for schools that have smaller class sizes, the availability of support services, a high amount of technology, and an in tact physical infrastructure.

Conversely, if these things are not present, the higher income individuals will move out thereby decreasing the total income of the area and increasing the crime rate.

## Funding and Demographics

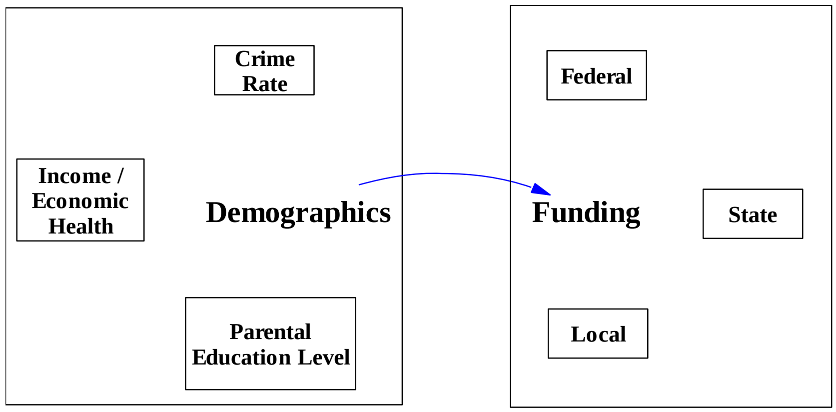


**Figure 13: Impact of Demographics on Funding**

Figure 13 shows the impact that demographics have on funding. Funding for schools is based largely on two different sources: income generated through local taxes and through government programs. The amount of income generated through local taxes will increase as the income level of the area is increased. Those with higher income generate larger amounts of revenue for the schools. Money coming from government programs is often based on the poverty level of the community. As the poverty level increases so will the amount of money allocated to the school.

The following section will begin our look at the No Child Left Behind Act and how it impacts the achievement and academic strength of a school.

### *Overview of No Child Left Behind*

The No Child Left Behind (NCLB) Act was enacted in 2001 as a way to try and solve many of the education problems facing America. The NCLB Act cites studies that show that 70 % percent of inner city fourth graders are unable to read at a basic level on national reading tests, that high school seniors trail countries such as South Africa and Cyprus in international math tests, and that the achievement gap in America has not been lessened (NCLB, 2002). The federal government has tried to fix many of these problems on a case by case basis and have mostly met with failure (McCluskey, 2004). The NCLB Act is an overarching piece of legislature that attempts to solve many of America's educational woes in a systematic way.

The main goal of NCLB is to help those students who are at a disadvantage to reach the level of the average student. Some of the other goals of NCLB are to increase literacy, to increase math skills, and to improve the overall educational setting for students and teachers. The main tool used to achieve these goals in NCLB is accountability. Accountability comes in the form of standardized tests and Adequate Yearly Progress (AYP) goals. Federal funding is given to states, districts, and schools with the understanding that if they are unable to improve results they will be financially penalized and if they are able to improve results they will be rewarded. Those schools that succeed receive reward funding and can spend that money in many different ways, providing these schools with flexibility. Those schools that are unable to reach their AYP goals are reprimanded by losing flexibility within their budget. After two years of failing, schools have to begin spending their money on school choice options for their students. After three years of failing to reach their goals a school must provide supplemental services such as tutoring to their students. After four, five, and six years of failure, corrective action and restructuring occurs, which includes such things as replacing staff, implementing new curriculum, or reopening the school as a charter school. These remedial actions account for a large percentage of the school's budget, not leaving place for flexibility. Flexibility in the budget allows for spending on such things as new technologies, new teachers, or improvements in the overall school infrastructure.

The following sections or titles illustrate and outline the main objectives and programs of NCLB (NCLB, 2002):

Title I – Improving the Academic Achievement of the Disadvantaged
Title II – Preparing, Training, and Recruiting High Quality Teachers and Principals
Title IV – 21st Century Schools
Title V – Promoting Informed Parental Choice and Innovative Programs
Title VI – Flexibility and Accountability

These titles provide the basis for this investigation into the behavior of NCLB and its effectiveness in achieving its goals.

***Literature Review: Impact of NCLB***

This section summarizes recent research and literature on the impacts of NCLB. The section concludes with a brief explanation of how this thesis contributes to that discussion.

The Center on Educational Policy (CEP) is "a national, independent advocate for public education and for more effective public schools. The Center helps Americans better understand the role of public education in a democracy and the need to improve the academic quality of public schools."(CEP, 2008) CEP is funded by the U.S. Department of Education and works to help policy makers and implementers to better use policy to improve schooling and learning. The Center has been developing an ongoing report analyzing No Child Left Behind throughout the years. This report entitled "From the Capital to the Classroom," analyzes the effectiveness of NCLB at the end of every school year, beginning in 2001-02. The analysis includes a survey of education officials in 50 states, a nationally representative survey of 299 school districts, and in-depth case studies in 38 geographically diverse districts and 42 individual schools. This in depth analysis helps to see how NCLB is impacting the educational system. The results of these studies are varied. The report states that overall test scores are rising. Problems such as decreased time spent on certain subjects, raised teacher stress levels, and an ever increasing burden on urban school districts have come about and have been reported. Also, some states report that the adequacy of federal funding is a serious challenge in accomplishing NCLB goals. This study does not go into great depth with any single element (such as school choice, funding, or demographics) of No Child Left Behind, but it does allow for a good overview of the many of the elements of No Child Left Behind.

The RAND Corporation is conducting a national longitudinal study of No Child Left Behind. The RAND Corporation is a non-profit research institution whose purpose is to aid in improving policy and decision-making. The RAND study looks at the impact of No Child Left Behind in many of the most populated districts across the country. The study provides an in depth analysis of school choice, supplemental educational services, and student achievement. The RAND studies have shown that No Child Left Behind remedial programs like school choice and supplemental educational services are increasing the performance of students who participate, but they are being underutilized

(RAND 2007). It also provides in depth analysis on the type of students that are choosing these programs and the general characteristics of the students that do well on standardized tests.

Robert L. Linn of the University of Colorado at Boulder is one of the foremost researchers in the study of accountability in the educational system. His work on the accountability standards of NCLB and accountability as a whole are extremely important because of the emphasis NCLB places on accountability. Many of his studies have shown that states and schools generally inflate and generalize gains made when it comes to standardized test scores (Linn, Baker, and Betebenner, 2002). That is, some states neglect to mention failures in specific areas, but discuss overall gains. His research calls for a need for improvement in the validation of these gains, especially under high stakes conditions, such as those in No Child Left Behind. He has done research on how NCLB testing could be improved and how schools, districts, and states could be held more accountable.

### *Using System Dynamics as a Simulation and Evaluation Tool*

A search of the literature on No Child Left Behind failed to find any use of System Dynamics as a tool for understanding the dynamic impacts of this policy on local school districts. This thesis is an attempt to join together the system dynamics problem solving methodology with current research in order to provide an integrated framework for integrating the findings from these studies.

The system dynamics methodology was developed at the Massachusetts Institute of Technology in the 1950's as a way for business managers to analyze complex issues impacting their business (Sterman, 2001). System dynamics is a methodology for studying and managing complex feedback systems, such as one finds in business and other social systems. Feedback refers to the situation of X affecting Y and Y in turn affecting X perhaps through a chain of causes and effects (Spencer, 2008). System dynamics is based on the premise that greater insight and better decisions are possible by studying the underlying, time-dependent dynamics giving rise to the problem of interest. In the case of No Child Left Behind, it is important to understand every element in the system and how those elements interact in order to understand the system as a whole. This understanding allows for a more complete evaluation of No Child Left Behind, thereby enabling more informed decisions by policymakers. It allows us to understand the most crucial system elements and how they affect the system.

In system dynamics methodology, systems are represented as a combination of stocks and flows. A Stock can be metaphorically thought of as a bath tub, while flows can be seen as faucets (inflows) that fill up the tub, or as drains (outflows) that drain the tub.

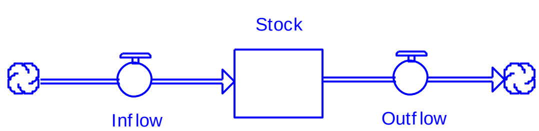


**Figure 14: Example of a Stock and Flow Structure**

In a system dynamics model, stocks generally represent something that accumulates over time, such as population, pollution in the air, or money in a bank account. Flows change the rate of accumulation or depletion in the stock over time. Some examples of flows can be births, deaths, immigration, the release of pollutants into the air, or the purging of those pollutants from the air, anything that causes the stock to gain or lose volume.

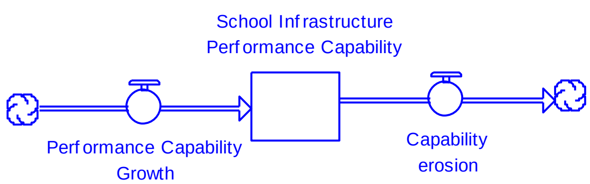


**Figure 15: Example of a NCLB Stock and Flow Structure**

An example of a stock and flow structure that is relevant to this current study is shown in Figure 15. This figure is a simplified stock and flow structure representing the change in school system's infrastructure as it improves or erodes over time. In particular the accumulation of School Infrastructure Performance Capability is increased as the Performance Capability Growth flow rate is increased and decreased as the Capability Erosion flow rate is increased. The rates at which these flows change the School Infrastructure Performance Capability are affected by other elements of the system (not shown in the diagram). As the model is expanded, these variables are explicitly represented on the diagram. Examples of such variables are erosion rates, spending schedules, and funding rates.

A system dynamics study typically progresses through six steps (Sterman, 2001). These steps are:

- problem articulation,
- developing a dynamic hypothesis,
- building a computer simulation,

- testing the model to be sure it reproduces the behavior seen in the real world,
- devising and testing alternative policies to alleviate the problem, and
- implementing the solution.

The two most important steps in this methodology are the first two steps. These two steps will be covered in this section. The final four steps are included within the rest of the paper.

This first step (problem articulation) defines the problem of interest in terms of dynamic behavior over time. The researcher identifies the dynamic behavior to explore and why it is important to understand this behavior. This step sets the boundaries, scope, and variables that will be used within the model. In the case of this model, the change in school achievement over time is the dynamic behavior that needs to be understood. This is done by exploring the impact of remedial spending long term infrastructure demographic and socioeconomic makeup of the area, the funding process, and graduation/drop out rates.

The second step involves creating what is called a dynamic hypothesis. A dynamic hypothesis is the explanation the modeler gives for the system's behavior. The dynamic hypothesis seeks to explain the behavior of the system in terms of the relationships between the main variables in the system and the feedbacks and delays that arise from these relationships. The key to a good dynamic hypothesis is to use a broad enough boundary for the model to encompass the most important variables in the system. That is, the primary "causes" of the system behavior should be explained in terms of the feedback dynamics in the model, not by external forces that operate independently our outside of the dynamics represented in the model.

For No Child Left Behind many have argued that the policy is solid, but under-funded (Keller and Sack, 2005). Others have said that No Child Left Behind's emphasis on accountability has and will continue to aid in the improvement of student achievement (Boehner, 2004). Also, some have stated that No Child Left Behind only truly aids those schools that are only partially behind, but not those that are drastically failing (Herman, 2007). All of these and other such factors interact in intricate ways. Many people will only look at one of these hypotheses, which causes people to react rashly and call for policy change. A dynamic hypothesis seeks to describe the dynamics underlying system behavior in broader terms, rather than in simple "A caused the problem" terms. In the case of this paper the goal is to explicate a set of dynamics that can explain why one school system is performing well while another is not.

In a nutshell, the dynamic hypothesis proposed herein suggests that the difference in student performance within Palm Springs and Sacramento City can be attributed to the dynamic relationships between NCLB policies, the quality of school infrastructure, the flow of funds into the school district, and the evolving demographics of the surrounding community. These dynamics are present in both school systems. However, they result in different outcomes because of a different quality of school infrastructure and the impact of restrictions placed by NCLB. The next section takes a closer look at this dynamic hypothesis and the dynamics of the system.

### *Dynamic Hypothesis: No Child Left Behind and School Performance*

This section will look at the behavior of No Child Left Behind. The figures seen in this section were created using a piece of modeling software called Vensim. Vensim was used to create Causal Loop Diagram (CLDs) to show the interaction between the different variables affected by the policies in No Child Left Behind (Sterman, 2001). The causal links between the different variables will have either positive or negative polarities (represented as '+' or '-'symbols by the causal connection arrows in the CLD). A positive polarity signifies that changes in the "cause" variables will result in changes in the same direction in the "affected" variable. A negative polarity means that changes in the "cause" variable result in changes in the opposite direction in the "affected" variable. The figures shown below displays feedback loops that are either reinforcing or balancing. A feedback loop occurs when a variable impacts other variables which in turn impact the initial variable in some way. It is these loops that make up the critical dynamics in the system (***ibid***). A reinforcing loop will create unfettered growth or decline in the variables in that loop. Balancing feedback loops seek steady state or equilibrium behavior of the variables in the loop. If a reinforcing loop dominates a system, then the system will experience runaway growth or a "death spiral" of decline. If a balancing loop dominates, then the system will eventually migrate toward a steady state or equilibrium performance level. The system in which No Child Left Behind operates involves both reinforcing and balancing loops. The combination of these loops helps to provide us with a deeper understanding of the potential impact of this policy.

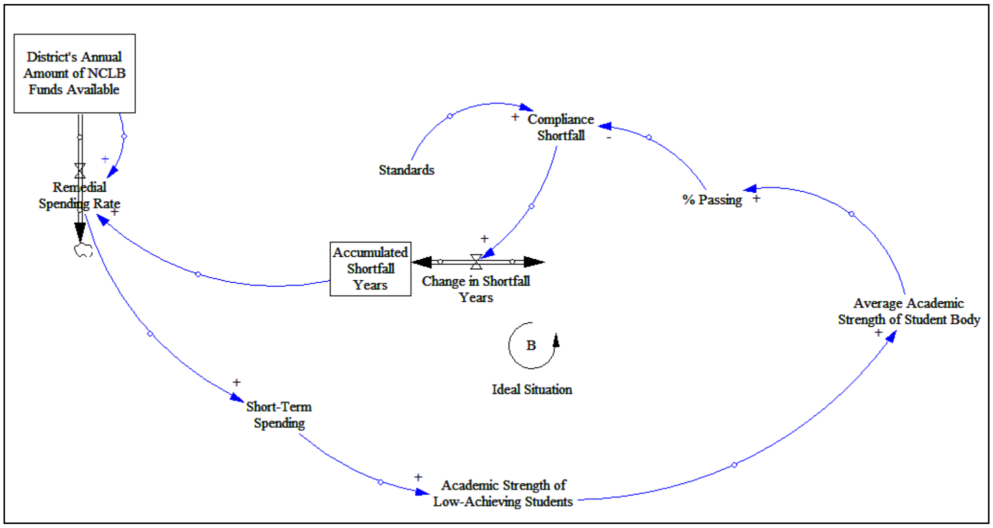


**Figure 16: Causal Loop Diagram showing the Ideal Situation for No Child Left Behind**

The main goal of No Child Left Behind is to help low achieving students raise their overall level of performance to that of high achieving students in order to increase the overall strength of the student body. The Ideal Situation balancing loop in Figure 16 illustrates how No Child Left Behind is intended to accomplish this. In this way, Figure 16 represents the "mental model" that motivated NCLB. As a school continually fails to reach the standard set by No Child Left Behind, it accumulates a number of compliance shortfall years. An increase in the number of consecutive shortfall years forces a school to spend more money on remedial programs. As the amount of money spent on short term programs, such as tutoring, increases, the academic strength of the low achieving students increases. This will cause an overall increase in the average strength of the student body, which will cause more students to pass the standardized tests set forth by No Child Left Behind. When working on its own, this loop calls for an increase in funding for short term programs enabling low achieving students to improve their academic status. Since this is a balancing loop it has the ability to control and stop continuing failure.

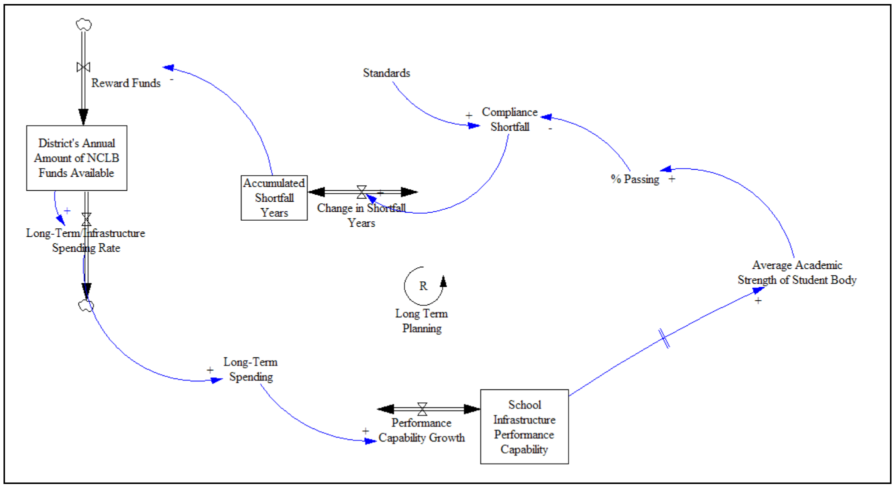


**Figure 17: Causal Loop Diagram showing the Long Term Planning for No Child Left Behind**

Short term programs alone are not enough to keep a school successful over a long period of time. Long term planning is needed in order to ensure that is school is able to maintain a level of performance over a long period of time. As a school increases its investment in long term improvement, the capability of the school's infrastructure to improve performance begins to increase. Hiring more teachers, improving access to technology, and improvements in the physical infrastructure of the school are just a few long-term investments that eventually help the school improve student performance. As student performance and the amount of students passing standardized tests increases, the school will continue to receive funding towards long term infrastructure improvement. As a reinforcing loop it can be seen that this focus on long term planning can cause a continual increase in standardized test scores. If this loop dominates the system, NCLB will prove to be a success.

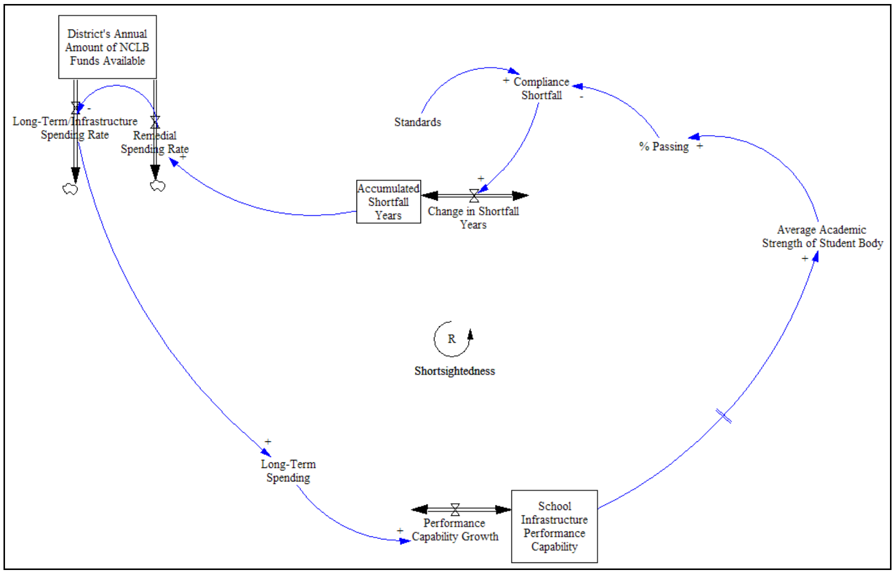


**Figure 18: Causal Loop Diagram showing the Shortsighted outlook of No Child Left Behind**

One of the main negatives of No Child Left Behind is that it can force shortsightedness on a school. The previous loop looked at how a commitment to long term infrastructure growth can cause an improvement in student performance. This reinforcing loop illustrates how an increase in remedial spending will cause a decrease in the amount of money spent on long term infrastructure growth. As the long term spending decreases, the ability for the school infrastructure to provide an adequate learning environment also decreases. This will eventually cause a drop in the average academic strength of the student body, overriding much of the positive impacts of the short term programs installed by No Child Left Behind. The main issue with this loop is that as the number of students not passing the standardized tests increases, the amount of money spent on long term infrastructure spending will continue to decrease. Since this is a reinforcing loop, it has the potential to send a school into a "death spiral" of ever decreasing performance. As more and more funds are directed to remedial spending, less is spent on long-term improvements in infrastructure, thereby leading to even poorer student performance, causing even more remedial spending, and so on.

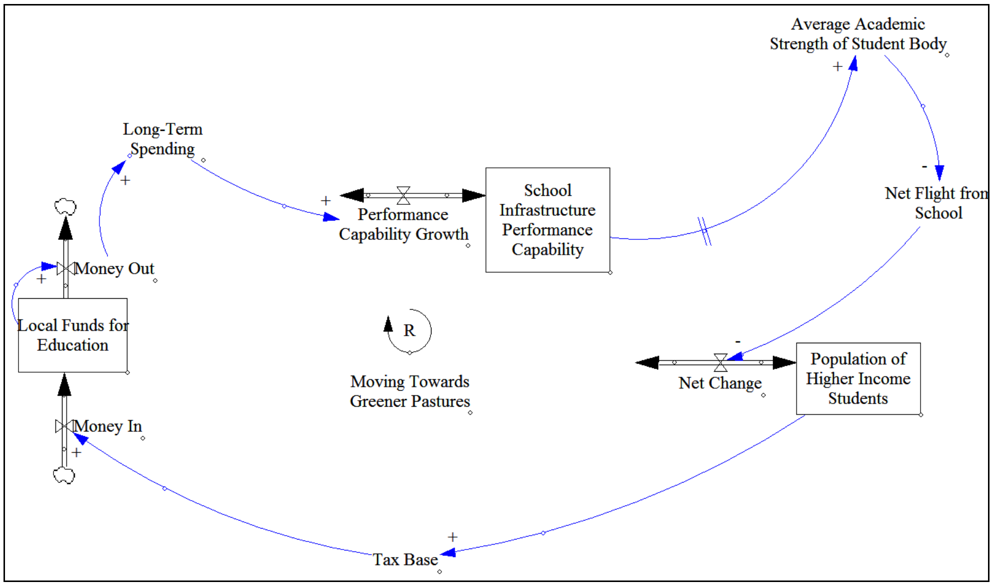


**Figure 19: Causal Loop Diagram showing the impact of School Choice and the movement of students into and out of the schools**

After failing to reach compliance for three consecutive years, a school must provide their students a choice to leave and attend a better performing school. This seems like a good idea in theory, but in practice it can produce mixed results. As higher income students leave the area to attend other schools, the tax base in the surrounding community begins to erode, causing a decrease in the amount of funds available to be spent on long term spending (Dillon, 2008). With a lack of funds, the school's infrastructure will inevitably decay, further hindering student performance. The school will look less desirable, causing even more students to want to leave, leaving behind those students that do not have the ability or desire to flee. This loop illustrates one of the main negatives of school choice, which is that the low risk students will continue to flee a poor performing district. As stated earlier, many of the low risk individuals' families are more affluent. This could rob the local area of its tax base, and condemn those who are left behind (i.e. high risk individuals, low income families) to an increasingly poor quality school. The better schools will continue to receive the higher performing students, where, in turn, these students will receive a better education. The poor performing schools will continue to lose the better performing students and will continue to have their infrastructure degrade even further.

## Chapter 2: Overview of Model

### *Intended use for the Model*

The purpose of this thesis is to model the dynamic behavior student performance in the presence of No Child Left Behind in two California school districts. The ultimate goal is to simulate how the underlying dynamics lead to different outcomes in each district.

This model will embody one hypothesis about how one school district is able to maintain a high level of success, where another school falters under NCLB. The hypothesis and model are validated by comparing model output with the known evolution of student performance in each district in the period from 2002 to 2006. System dynamics will allow us to incorporate the relationships that are present within the school district in order to see the behavior that arises from these relationships. This behavior will help to explain how school performance is impacted by the many elements within the school district. Understanding why one school or school district fails and another succeeds will allow us to extend the benefits of the model even further.

By allowing a user to change certain parameters in the model, different behaviors will arise, and a deeper understanding of the problem is possible.

The model was developed using Stella® version 9.0 (http://www.iseesystems.com). The user will be able to make changes to the initial settings of the school system in order to customize the model to fit many different school settings. The user can set the initial economic strength of the community, the population of the community, the quality of the current school infrastructure, and many other factors. This model will also allow the user to try out different required pass rate schemes and school restructuring choices. These and other variables will allow the user to set up many different scenarios to analyze and simulate the impact of No Child Left Behind.

### ***Overview of Model Structure***

The following sections describe the model structure and logic. The model mimics the behavior of student performance within a high school. The reasons for this restriction on the model will be discussed in a later section. In order to simplify the model development and testing, this model was divided up into different sectors. This division allows the overall model to be easier understood, since it has been broken down into smaller, manageable parts. The sectors in this model are:

- The ***Funding*** sector, which shows how funding in a school system that falls under No Child Left Behind works. It consists of stocks that are made up of the amount of funds received from No Child Left Behind, local taxes, and state funding. The inflows and outflows consist of the funding rates for each of these stocks and then the disbursement rates towards either remedial funding or long term funding. The amount of funding for

No Child Left Behind is based upon the number of low risk students (high income, educated parents) and the number of high risk students (low income, uneducated parents). The more high risks students, the more funding that school will receive. The local taxes are determined through the number of economic contributors and detractors there are in the community. An economic contributor is someone who receives a larger income and has a high level of education. They are self-sufficient and give back money in the form of taxes and possible charity. The larger the amount of economic contributors, the larger the amount of money from taxes will be. An economic detractor is someone who may need some help and money from the government. These individuals have a lower income, have less education, and pay less in taxes. These labels do not permanently apply to individuals, but it does take a considerable amount of effort to move from being a detractor to a contributor. The state funding is based on the size of the student population at the school. Funding comes from three different sources (federal, state, local) and is then allocated to different programs, long term or remedial. The long term spending is assumed to impact the school infrastructure sector (described in detail below), while remedial spending impacts programs such as support services which were mentioned in Chapter 1. Both long term spending and remedial spending have a large impact on student progression and achievement and are the main crux of the model. It is assumed that long-term spending will necessarily lead to improvements in student performance over time. That is, the model makes the simplifying assumption that long-term spending decisions are effective and give the desired results. Likewise, it is assumed that insufficient long-term spending will result in an inevitable (but slow) deterioration in the school infrastructure, leading to an eventual decline in student performance.

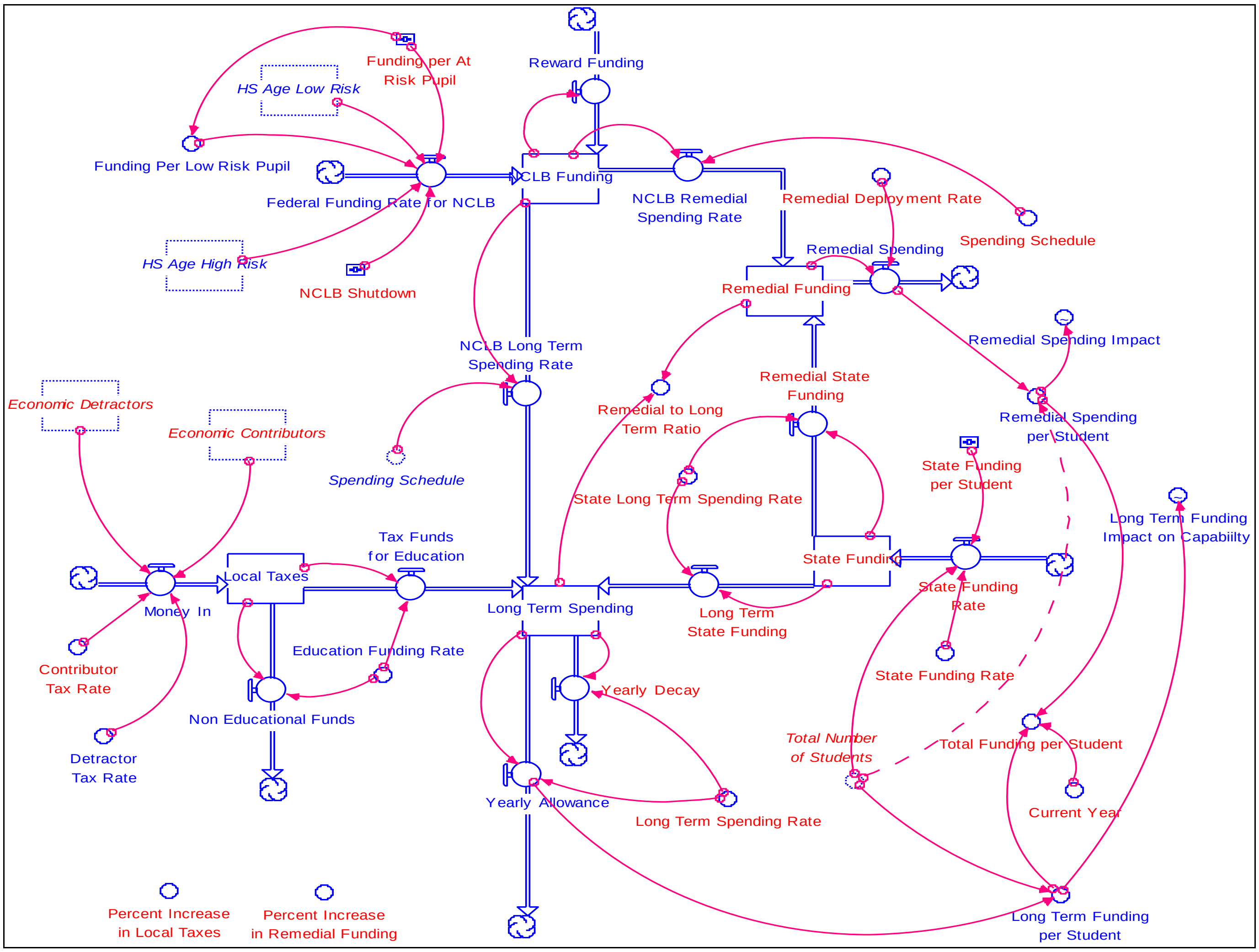


**Figure 20: Funding Sector of the Stella Model**

- The ***School Infrastructure*** sector models dynamic changes in the capability of the school's infrastructure to support student performance. It consists of a basic stock and flow structure that increases or decreases the capability of the school to sustain a long period of educational success. Long term school infrastructure consists of such things as the quality of teachers in the school, classroom size, student to teacher ratio, available technology, and the actual physical infrastructure of the school itself. It is impacted by the amount of long term funds that are spent per student. It is also impacted by the erosion factor of the school, which is determined by the amount of attention the school is paying towards maintaining a high level of infrastructure. The school infrastructure has a large impact on student performance and the ability for students to increase their achievement level.

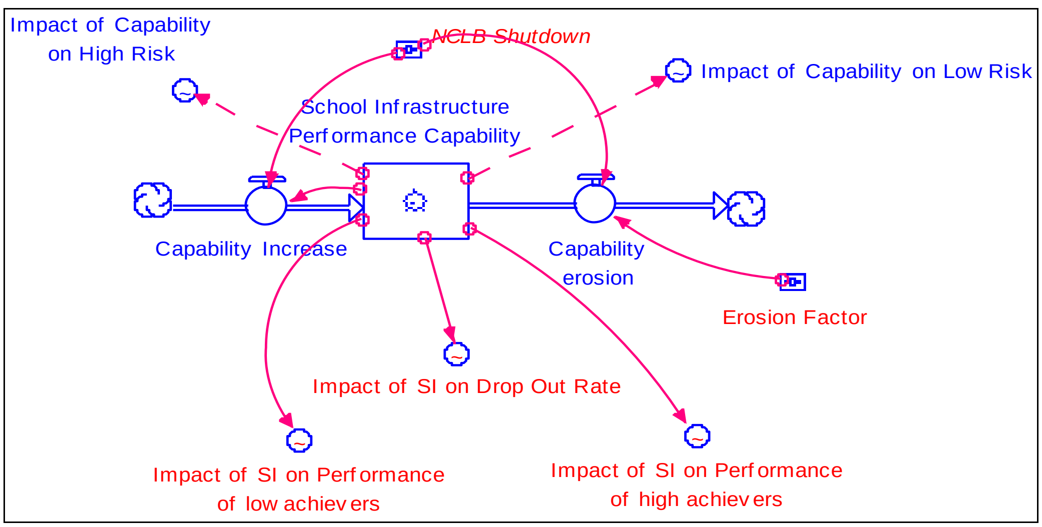


**Figure 21: School Infrastructure Sector of the Stella Model**

- The ***Demographics and Student Progression*** sector, which mixes together two elements of this model that are very closely linked. The main demographic element that is considered in this model is the economic health percentage of the area. This consists of the poverty level of the area. This economic health index is determined by the percentage of children that can be considered high risk or low risk when entering into a school. The stock and flow structure in this sector is divided between these high risk and low risk individuals both moving from pre-high school age, to high school age, and then on to post high school. High risk individuals have a lower chance than low risk individuals of graduating and of doing well on standardized tests. Over time, the percentage of individuals moving between high risk to low risk status is affected by such factors as remedial spending and infrastructure capability. Those that graduate from high school become economic contributors to society and those that drop out become economic detractors. These two stocks (high risk, low risk students) help to determine the economic health of the area. This stock and flow structure also allows for births and deaths, as well as, individuals moving in and out of the area. Emigration and immigration are impacted by the community quality index of the area, which consists of the economic health index and student performance (which is discussed in the Achievement sector). A high community quality index will cause low risk families to move into the area, while a low community quality index will cause low risk families to move out seeking a better community.

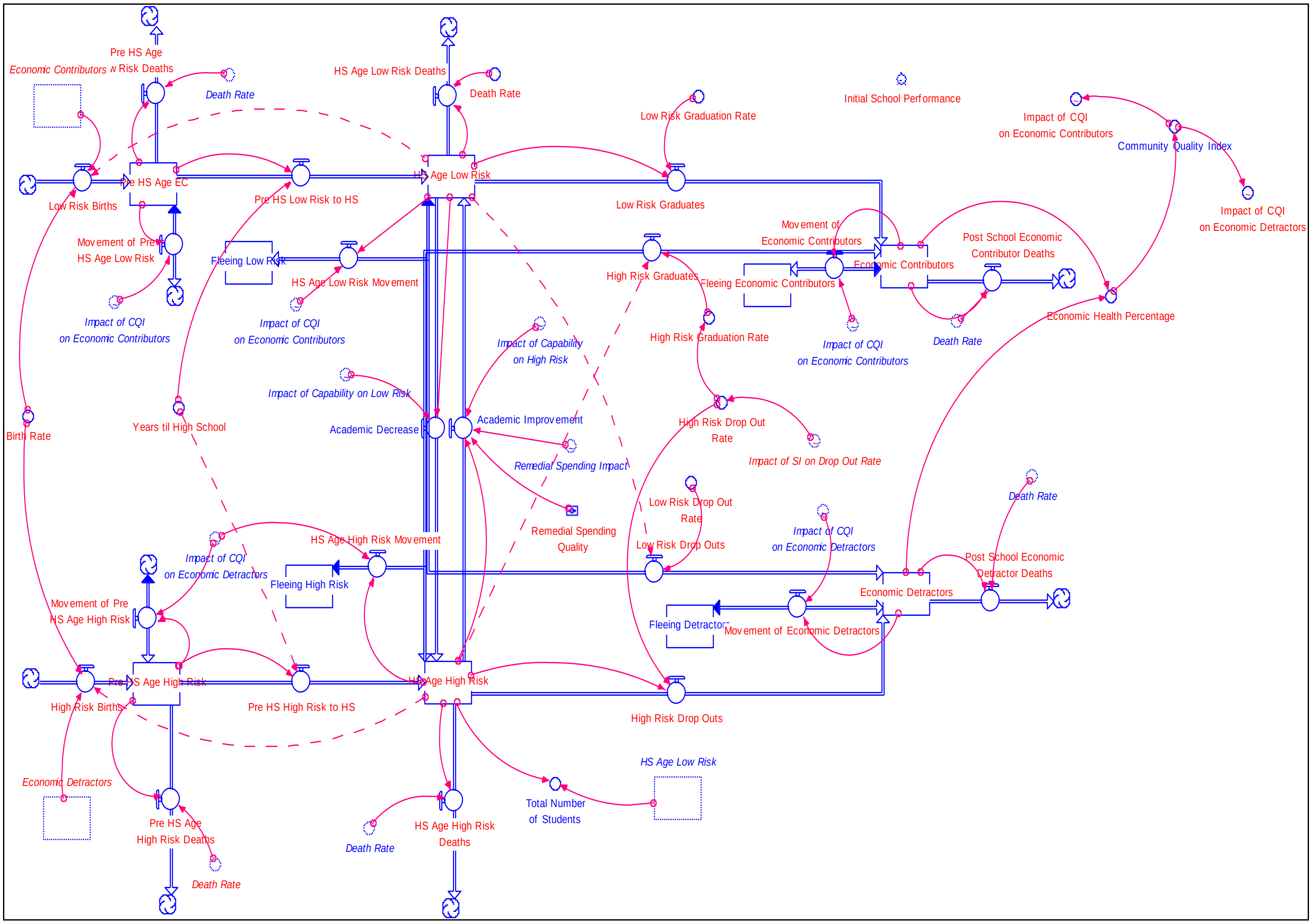


**Figure 22: Demographics and Student Progression Sector of the Stella Model**

- The ***Achievement*** sector makes up the most important element of the model. The achievement sector encompasses student performance on standardized tests. Student performance is determined by looking at the number of high risk and low risk students and then combining that with an assumed rate of passing for each of these groups. The assumed pass rate of these groups can be altered based upon the capability of the infrastructure, meaning that a highly capable infrastructure will aid in helping more low achieving students to pass the standardized tests. The assumed pass rate for low and high achieving students was determined by experimenting with the model. These rates were simply assumed and not determined through data from either of the districts. The stock and flow structure in the achievement sector includes the consecutive number of years that a school has failed to reach Adequate Yearly Progress. AYP is determined using the required pass rate, which is set by the No Child Left Behind requirements. Alternative required pass rates are offered within the model, but the current required pass rate is what will be used for testing the model. If the overall student performance of the school is less than the required pass rate, than the number of consecutive shortfall years will increase by one. If a school is able to keep their performance above the required rate for two years straight, then they will be able to lower their number of shortfall years to zero. This stock and flow is the main way that the federal funding rates and types of expenditure (short-term remedial vs. long-term infrastructure) are determined. The higher the number of shortfall years, the greater the amount of money that will go towards remedial spending.

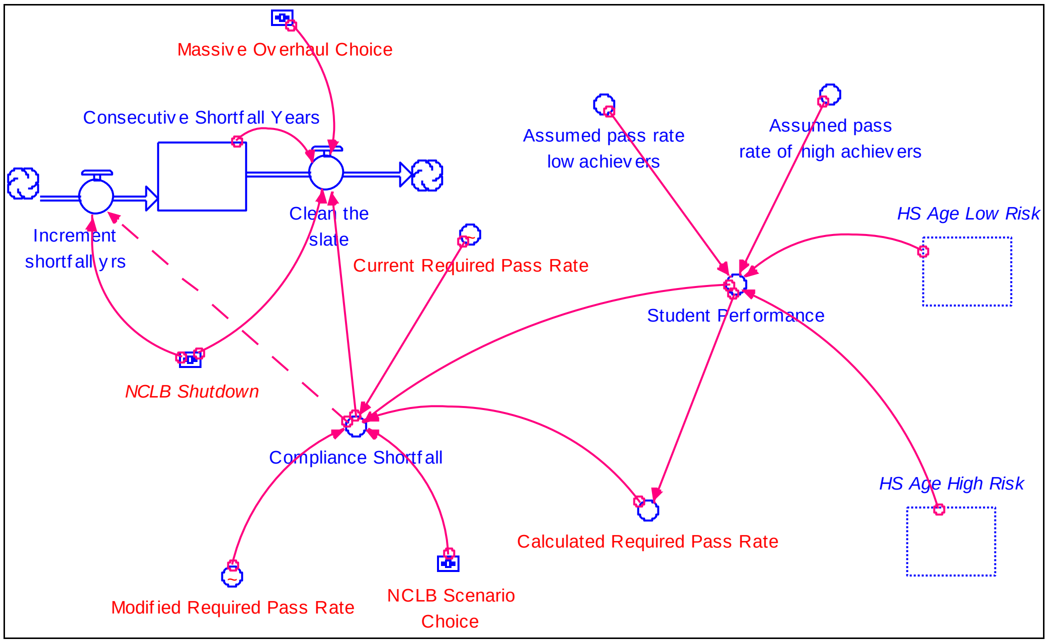


**Figure 23: Achievement Sector of the Stella Model**

### *The Original Mental Model for the No Child Left Behind Policy*

The main purpose of No Child Left Behind is to make schools and districts accountable for increasing the performance of their students. Policy makers believe that student performance will increase because the increase in accountability will force administrators and teachers to do better than they are currently (NCLB, 2002). Schools that are doing poorly are reprimanded and forced to spend money to help those students that are performing poorly. Schools doing well are rewarded for doing well. So, it is logical to think that No Child Left Behind should help to improve schools in need and help schools that do well to sustain success. This creates the original mental model that motivated the No Child Left Behind legislation. A mental model represents the way that something is generally perceived to behave. Lawmakers believed that NCLB would provide support to schools in need through accountability and remedial programs and will keep these schools from falling back into failure. So, in essence, this is the best case scenario for NCLB. The following few paragraphs will look at how the Stella model can represent the best case scenario.

In order to increase performance in low performing schools, NCLB provides funding that can be allocated where it is needed. At the start of NCLB before schools begin to fail to reach adequate yearly progress, these funds can be spent on increasing the long term infrastructure capability of the schools. The funds can help poorer schools to shore up the physical infrastructure or bring in new technology. These and other such changes to infrastructure have a large impact on the performance of students. NCLB also provides another level of accountability for these schools. As stated earlier in the overview of NCLB, schools must begin to spend some of their NCLB funding on remedial programs such as tutoring and school choice in order to help out poor performing students. These programs can have a great impact on performance.

NCLB also helps schools to maintain a high level of performance over time. As a school continues to succeed they are given rewards in the form of extra funding that can go towards a large number of things to improve the infrastructure. This increase in funding allows schools to focus on sustaining and improving their infrastructure capability. The improvement in infrastructure capability will continue to aid in increasing the test scores of the high risk students. As stated earlier, reaching and maintaining a high level of performance should be the key of every school and school district.

NCLB also places a strong focus on those schools that continuously fail. After failing to reach AYP for five consecutive years a school must begin to plan for restructuring. If they fail the next year, they must implement this plan. There are many options for school restructuring under NCLB. NCLB states that restructuring plans must show a commitment to improving performance in order to reach AYP. This model allows you to see what would happen under each of these different options. Since NCLB is a relatively new piece of legislation that has only been in effect for the last six years, research on these restructuring plans is quite limited. Assumptions on how these options would impact student performance were made through research on school districts and schools that have implemented such plans in the past outside of the realm of NCLB. The following will look at these options and how they are implemented within the model.

- **Chartering and Contracting**: The first two options under No Child Left Behind are chartering and contracting. The charter option calls for a district to close a school and then reopen as a public charter school. Students have a choice whether or not they want to attend this school. Changing to a charter school gives districts a large amount of authorization over that school. These charter schools fall under charter law and so are restricted by the state's charter school laws. They first turn the school over to an external group. This external group can make changes to the school as they see fit, such as a different curriculum or longer school days, without having to ask special permission. Districts then have the control to get rid of this group if they feel that they are not doing a good enough job. The contracting option behaves in much the same way as charter schools, but contracting does not have as many laws in place to regulate the type of contract that is created with the external group.

In this model, choosing either plan helps to increase the assumed pass rate of the low achieving students. Studies show that charter schools are better able to reach those students who are low achieving because of their ability to change the way that the school is run (Hassel, et al, 2006). Charter schools allow for a high level of customization and flexibility. On the downside, there is the possibility that some low risk students will choose not to attend this school because of the change in the way the school is run (ibid).

- **Turnaround:** The next option under NCLB is to replace staff members that were seen as a reason for the school's failure. This could include the principal, vice-principal, teachers, or any other staff member that are relevant to the failure. Research shows that complete staff replacements are not a good idea, but that hiring a very skilled leader to be in charge of making minimal replacements works well (ibid). By replacing those teachers that performed poorly and then hiring high quality teachers in their place, this plan allows for both quality teachers and students to benefit.

In this model, the turnaround plan has an impact on the capability of the infrastructure to help the students. High quality teachers and administrators are keys to success and this plan helps to bring in or keep these individuals in place. The possible negative of this restructuring program is that it may not be drastic enough. It can help the infrastructure in the short term, but it only impacts the teaching and administration aspect of it.

- **State Takeover:** Some districts will realize that they are unable to handle the financial and organizational challenges that come with restructuring. If this is the case, they may try the state takeover option. With this option, schools are taken over by the state government who assume the control of the failing schools. This option takes away control and possibly funding from the districts. The state government can possibly better handle the changes that need to be made to school and to the infrastructure.

  In the model, this option is shown through an increase to the school infrastructure capability. Research shows that a state government would come in and shore up the infrastructure, but with a lack of accountability they would neglect to keep fixing up the infrastructure causing it to possibly erode further (ibid).

- **Other:** This option could be anything that falls under the NCLB guideline that the plan is helping the school move towards reaching AYP. At this early stage of NCLB, this is the choice that most schools are taking. Generally, those that choose this option choose to do a handful of small changes, instead of the large changes seen in the other options. Some of the changes include professional development, new curriculum, reduced class sizes, experimental teaching methods, or many other options that could possibly help student performance. The administration will usually stay the same hoping that the above changes will be enough. Most of the time these changes have been unsuccessful (ibid).

In the model, if this option is chosen, the user will be able to decide what kind of impact it will have on the model. Since there are so many different ways this plan can be implemented, their have to be a number of ways it can impact the system. The model has it set up so that the user can impact the infrastructure capability, the impact of remedial spending, the impact on low achieving pass rates, and others. This is the basically the option where the user can experiment with a large amount of changes to find the most successful choice.

- **Close Down School:** The final option under NCLB is to simply close down the school. This option is for a school that either seems beyond repair or lacks anybody with the motivation to go through the tough restructuring process. Within the model, this option will not be available since it is simply the same as stopping the model from running.

***Unintended Consequences***

The previous sections have all discussed the potential positive impact of No Child Left Behind under the simplified mental model. That mental model fails to account for the feedback mechanisms that can lead to a death spiral for schools that perform poorly, or a "success spiral" for schools that begin with success. The improvement in student performance could be seen in the previous sections, but this does not tell the entire story of NCLB. The simplified original mental model of NCLB only works with the proper funding, participation in remedial programs, the ability to maintain infrastructure, and the ability to keep high performing students. This section will look at some of the unintended negative consequences that arise in real life from the dynamics associated with NCLB.

The main key to success for maintaining a constantly high level of performance is having a solid foundation to build upon. This foundation comes from the school's infrastructure. As mentioned previous times without a proper infrastructure, a school will falter. No Child Left Behind works fine when the school is doing well enough to keep its funding from becoming restricted to remedial programs. When a school is doing poorly, they are then forced to spend a portion of their money on remedial programs. This focus on remedial programs is fine in the short term, but it does not work in the long term. After a period of time, the infrastructure begins to erode negating any positive impact that the remedial programs had. If the infrastructure continues to fail, the school's performance will continue to drop, possibly past the initial performance level.

Another unintended consequence comes from the idea of school choice. After a school has failed continuously for a few years, NCLB allows students the chance to move to a better school. This sounds like a good idea, but when put into practice it is having trouble working (Gill, et al, 2008). The main problem with school choice is the fact that it is not the lower performing students that are using it; it is the higher performing students that are using school choice (Dillon, 2008). The high performing students generally have a higher commitment to education so they are willing to put up with the hassle of changing schools in order to get a better education. The lower performing students may not have the drive or simply do not have the financial means to go through changing schools. Even though NCLB forces schools to pay for transportation to and from the school, school choice is being highly underutilized by students that need it the most (Gill, et al, 2008).

The next chapter will show how this model went through the many types of testing that are used to validate and verify that a model is working properly. Chapters 4 and 5 will go into more depth with examples and of different experiments that can be run to show the impact of such things as school infrastructure, remedial spending, and overall funding levels. These chapters will use case studies and experiments to help demonstrate the dynamics that create high quality and low quality schools and school districts.

## Chapter 3: Validation and Verification of Model

Before this thesis move further into the results of the case studies of the two separate school districts and of other simulations, it is important to validate and verify that the model is actually useful and that it is doing what it is supposed to do. In other words, does the model fulfill its intended purpose? In order to answer this question, an assessment needs to be made about whether the model accurately addresses the system dynamics and behavior of No Child Left Behind and of student performance. Also, it is important to evaluate whether these issues are addressed in a way that will aid us in answering the main questions driving this thesis. The criteria that will be used to evaluate this system dynamics model are listed below (Sterman 2001)

- ***Face validity***: This criterion looks at whether or not the model has boundaries and that it includes variables that are pertinent to its purpose. As an example, are certain variables that have an impact on funding excluded (i.e. state funding, local taxes). If they are excluded, then the model boundary should be expanded to include the appropriate variables

- ***Structural validity***: This criterion basically tests whether the structure of the model is logical and that it conforms to basic physical laws. It looks at whether or not the relationships in the model are consistent with those in the real world. Examples of good and poor structural logic will be shown below.
- ***Dimensional consistency***: This criterion checks to make sure that the description of the variables, the numeric values of the variables, and their mathematical use are all consistent with the units that they are expressed within the model. You do not want to have .33 people or funding variables in births per year.
- ***Behavior under extreme conditions***: This criterion looks at whether the model is as sensitive as common sense would expect under extreme conditions. It checks to see if large changes in key variables are shown throughout the system in a way that research and common sense would suggest. An example would be to cut off all funding and see whether student performance dips exponentially as it should, or if it increases or stays where it is at, as it should not.
- ***Behavior reproduction***: The final criterion may be the most important. It looks at whether the model accurately represents relevant aspects of past behavior. Is the representation close enough to fit the needs and goals of the model? This criterion will be investigated in Chapter 4.

The following sections will look at these criteria and how they fit with the model. This will allow us to move on to the following chapters where this thesis will look at the case studies of the two districts, other simulation results, the impact of these results on legislation, and then changes and improvements that need to be made to the model.

### *Face Validity*

Face validity testing is the qualitative analysis of the model structure against what is being said by experts in the subject. It is important to understand whether the model correctly represents the relationships between variables in the real world. The expert knowledge for this model was gathered through extensive literature review and statistical analysis. Some of the literature review is discussed in the introduction, but a great amount of research went into defining and establishing the relationships between variables. By searching through journal articles, research studies, and other publications, a better understanding was gained as to what variables should be included in the model and how these variables interact with each other. Statistical analysis was done by searching through the State of California's STAR website. This website contains years of data on such things as graduation rates, drop out rates, demographic data, funding, and performance on standardized tests. This data helped to create a more logical set of relationships and also set boundaries based on available data. This combination of qualitative and quantitative data has helped to create a model that accurately represents the important dynamic relationships.

### *Structural Testing*

The next criterion, structural testing, takes a look at the model to ensure that it conforms to basic physical laws. Items cannot simply appear out of nowhere, there has to be some sort of reason that they appear in the model. In this model, the main testing is done within the student progression/demographics section and funding section. The number of students must be "preserved" in a given school (apart from emigration or immigration into the school district). Whether it is through emigration, birth, or through the movement from one age group to another, the population in these stocks should only consist of individuals that initially enter through a flow. If an initial population of 10,000 is expected, then the final population for the model should not be 500,000. It should fall within a range of values that can be expected, given the rates of immigration, emigration, birth, and death. These types of model checks compare initial values to the final results to confirm that these conservation principles are upheld. Within the funding sector it is important that all the money is accounted for in one way or another. The money should not simply appear out of nowhere nor should it simply disappear without reason. Within this model, all of the funding stocks and flows create a reasonable structure to replicate the way funding works within the real world.

***Dimensional consistency***

Another important and helpful criterion for validating a model is a check on the dimensional consistency of the model. As mentioned earlier, dimensional consistency involves making sure that the units used within the equations of the model are consistent throughout the model. Also, it involves making sure that the units used in the model make sense when compared to the real world. As an example, the stocks that contain funding are in units of dollars. So, all the flows that come in and out of this stock should be in dollars per time unit. This model goes in time steps of one year, so the funding flows are in dollars per year. Dimensional consistency is more difficult to maintain when moving from one stock and flow structure to another. This can be done through the use of converters. The yearly allowance flow is in dollars per year. This flow impacts the school infrastructure performance capability stock which is in performance units. In order to go from funding to infrastructure converters are used. One converter is connected to yearly allowance called long term funding per student which is in units of dollars per year per student. This converter is then connected to a converter called long term funding impact on capability which is in units of performance units per dollars per student. This would then connect to the capability increase flow which is in performance units per year which then feeds into the infrastructure performance capability stock. The equation from the yearly allowance flow to the infrastructure performance capability stock is seen below.

Dollars/Year * Dollars/Year/Student * Performance Units/Dollars/Student * Performance Units/Year -> Performance Units

Doing these types of checks on units throughout the modeling process helps to keep the dimensional consistency. Stella provides a handy tool that allows you to check your units throughout the creation of the model. These checks enable the modeler to find errors in the logic of the model and also to understand what type of variable or converter is needed at a given time.

***Extreme conditions***

Another important criterion used throughout the modeling process to evaluate the logic of the model is the behavior of the model under extreme conditions. By using the extreme values of certain key variables, the logic of the boundaries, assumptions, and equations used within the model were able to be tested. This criterion was used to examine several different variables. An example of extreme behavior that was checked was the amount of No Child Left funding per student. The funding rate was checked at zero dollars per student and then at double the normal funding rate. At zero dollars, the performance on standardized tests dropped and the ability of students to improve their standing dropped drastically. On the other hand, when doubling the funding per student, the performance increased as did the ability of students to improve their standing. Both of these examples behaved as expected. Some of the other variables that were tested in this same way were the capability erosion, economic health index, infrastructure capability, remedial spending quality, and initial school performance. The infrastructure sector showed a large sensitivity to change which is expected, since the infrastructure of a school has a great impact on student performance. The table below shows the results of some of the extreme condition testing that was conducted.

| **Variable** | **Test** | **Test Value** | **Expected Behavior** | **Observed Behavi** |
|---|---|---|---|---|
| NCLB Funding per At Risk Pupil | Funding per At Risk Pupil Cut in Half | 650 | A steady decrease in school performance will occur due to funding that does not meet expectations. | As Expected |
| NCLB Funding per At Risk Pupil | Double Funding per At Risk Pupil | 2600 | A steady increase in school performance will occur since long term funding can be accounted for. | As Expected |
| Capability Erosion | Complete Infrastructure Maintenance | 0 | School Infrastructure Capability will build up continuously, allowing school performance to increase greatly over time. | As Expected |
| Capability Erosion | No Infrastructure Maintenance, Capability Erosion increase by 50 % | 12 | School Performance will continually decline. | As Expected |
| Economic Health | Double Initial Economic Health | 100 | School Performance will increase greatly, as will the CQI. | As Expected |
| Economic Health | Minimum Economic Health | 0 | School Performance will decrease greatly, as will the CQI. | As Expected |
| School Performance | Double Initial School Performance | 100 | School Performance will dip dramatically, since infrastructure is not in place to uphold it. | As Expected |
| School Performance | Minimum School Performance | 0 | School Performance will be driven up quickly. CQI will increase due to this quick change in school performance. | As Expected |

| | | | | |
|---|---|---|---|---|
| Remedial Spending Quality | Double Impact of Remedial Spending | 2 | School Performance will slightly increase. | As Expected |
| Remedial Spending Quality | Cut Impact of Remedial Spending in Half | 0.5 | School Performance will slightly decrease. | As Expected |
| Infrastructure Capability | Double Infrastructure Capability | 100 | School Performance will increase and stay at a relatively high level. | As Expected |
| Infrastructure Capability | No Infrastructure Capability | 0 | School Performance will quickly decrease and will be unable to increase due to poor infrastructure | As Expected |
| Population | Maximum Population | 1000000 | Model behavior will remain constant over changing populations | As Expected |

**Table 2: Extreme Condition Testing Results**

## Chapter 4: Case Studies and Model Experiment Results

### *Behavior Reproduction and Case Studies*

Behavior reproduction for this model comes in the form of case studies of the Palm Springs Unified and Sacramento City Unified school districts. As stated in the introduction these two districts are similar economically and demographically. If this is so, how come Sacramento City Unified has shown positive results following the inception of No Child Left Behind and Palm Springs Unified has shown negative results? This section will how the model is able to reproduce the historical results within these two districts and then how the model is able to help forecast the future for these two areas. Doing this will show where and why one district is able to succeed while the other fails.

The first step in reproducing historical behavior is establishing accurate values for variables within the model. It is essential that appropriate values are used or the results will be useless. This section will describe how some of the most important values that were used in this model were determined and how they affected the model's results. Table 3 shows the initial values that were used for Palm Springs and Sacramento City.

| | Palm Springs Unified | Sacramento City Unified |
|---|---|---|
| Initial School Infrastructure Capability | 43 | 57 |
| Capability Erosion | 8.5 | 7.5 |
| Initial Economic Health | 0.2 | 0.22 |
| Remedial Spending Quality | 1.4 | 0.8 |
| NCLB Funding per At Risk Pupil | 1300 | 1300 |
| Initial State Funding Ratio | 0.65 | 0.65 |
| Initial Federal Funding Ratio | 0.08 | 0.08 |
| Initial Local Funding Ratio | 0.26 | 0.27 |
| Initial School Performance | 0.25 | 0.25 |

**Table 3: Initial Values for Model Testing**

In the introduction school infrastructure and its impact on school performance were discussed in detail. In the model, school infrastructure encompasses such things as teacher quality, classroom size, student to teacher ratio, available technology, and the physical infrastructure of the school. The model represents the ability of school infrastructure to help or harm students through the use of the ***School Infrastructure Performance Capability*** stock. The initial value for this stock is determined by a combination of the values for the above mentioned elements. The following graphs show the values for the two districts that are analyzed in the case study, as well as the average values for the state of California.

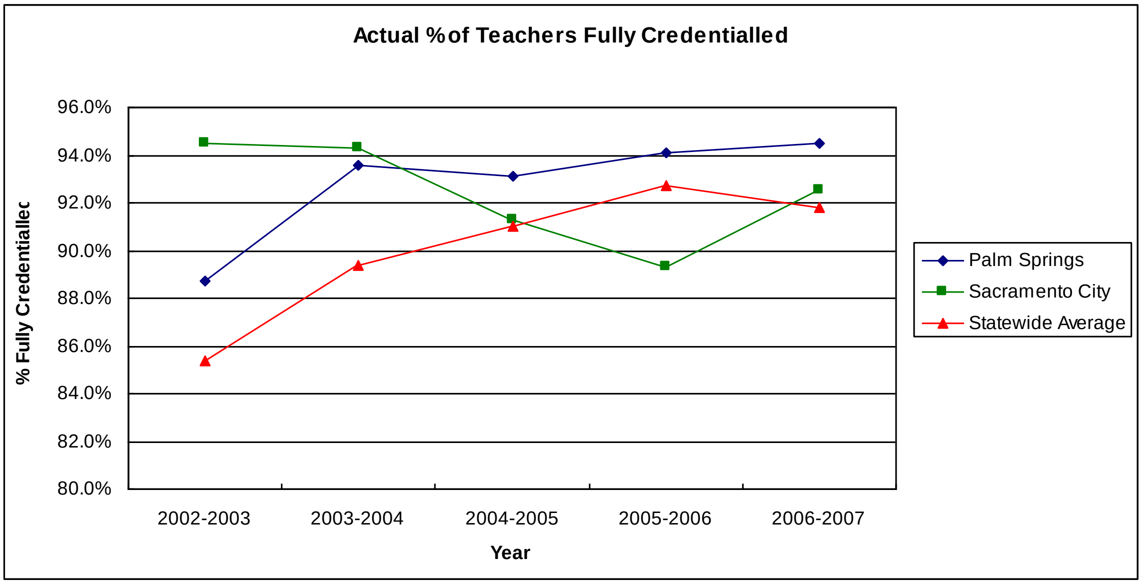


**Figure 24: Actual Percent of Fully Credentialed Teachers (Ed Data, 2008)**

Figure 24 shows that Palm Springs has an above average percentage of teachers that are fully credentialed meaning that they have gone beyond an undergraduate degree and have taken part in the proper accreditation programs. This is a good estimation of how well teachers are able to teach their specific subject matter (Haycock and Crawford, 2008). Sacramento City is close to the average for the state.


**Figure 25: Average Class Size for Both Districts (Ed Data, 2008)**

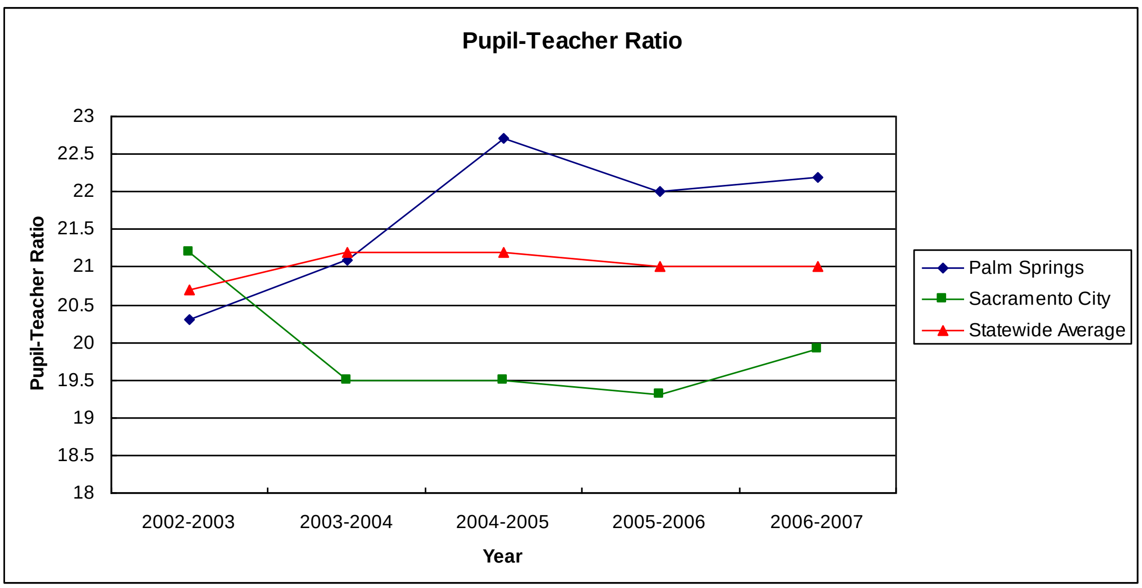


**Figure 26: Pupil to Teacher Ratio in Both Districts (ibid)**

Average class size and pupil-teacher ratio are two closely linked and very important variables within school infrastructure (Figures 25 and 26). They both have to do with the ability of a teacher to be able to spend one on one time with a student. Individual attention helps to alleviate discipline issues and to increase the retention of information (Haenn, 2002). It is tough for a teacher to be able to notice everything that is going on in a larger classroom. A larger classroom could also cause a student to feel lost and not important, causing them to neglect their studies (ibid). As the graphs above show, Sacramento City is much better than average in both classroom size and pupil-teacher ratio, while Palm Springs has lagged far behind over the last few years.

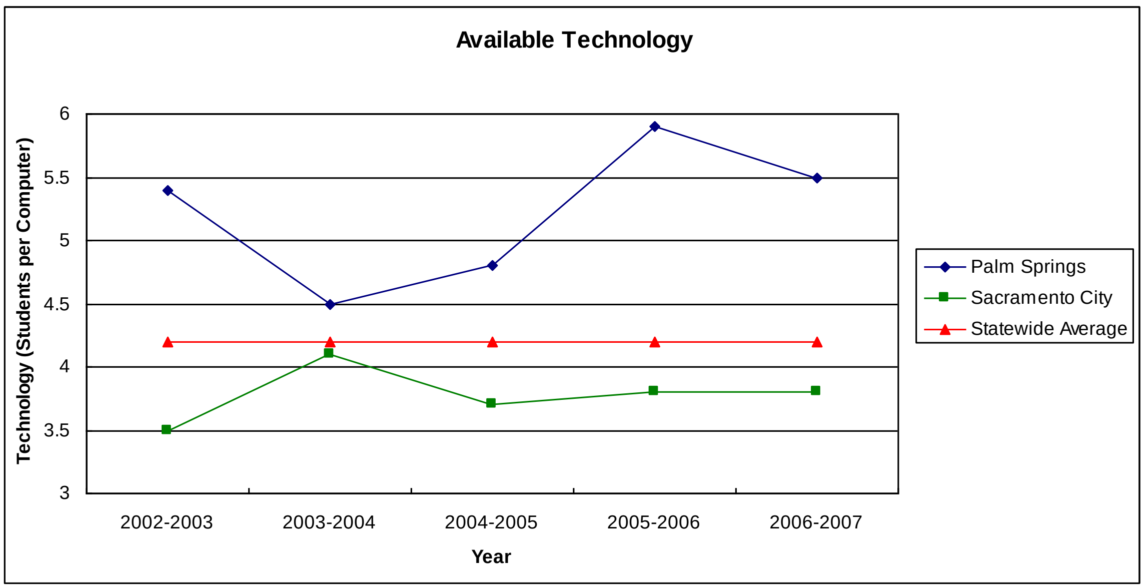


**Figure 27: Amount of Available Technology in Both Districts (Ed Data, 2008)**

One final important aspect of school infrastructure that was investigated was the amount of technology available to students. Having computers available to students inside the school is a very important piece of helping to improve student performance. Many students, especially in lower income areas, do not have access to computers or the internet at home and technology within the school is their only way to use a computer. Also, certain individuals learn better by using a computer because it allows for a more visual representation of what the instructor has been presenting (Jeffs, et al, 2006). As Figure 27 shows Palm Springs Unified averages around 5.5 students per computer while

Sacramento City Unified averaged fewer than 4 students per computer. Looking at this you can see that Sacramento City is around the state average while Palm Springs Unified yet again falls behind.

As these graphs show, Palm Springs is better than average in the amount of teachers that are fully credentialed. Sacramento City is better than average in classroom size, pupil teacher ratio, and available technology, as well as physical infrastructure which will be seen in the discussion of infrastructure erosion. Overall though, Sacramento City was around the statewide average in most cases. Using these graphs a value for Sacramento City that is slightly above average when it comes to the quality of its infrastructure and a value for Palm Springs that is slightly below average were determined. The average value for ***School Infrastructure Performance Capability*** is a 50 out of a 100, so 57 was used for Sacramento City and a 43 was used for Palm Springs.

An integral part of maintaining and improving school infrastructure is keeping a low ***erosion factor***. The erosion factor represents the amount of infrastructure that will erode away every year. Natural erosion occurs to the physical infrastructure over time, it takes money and time to be compensated for this decay. The movement of teachers in and out of the system, aging technology, and other such resource depletion occurs over time. A high erosion factor continues to decrease the school infrastructure capability.

To gauge the quality of the physical infrastructures of the districts and the erosion factor for these districts the amount of money going towards school upkeep had to be investigated, as well as, the pictures of the school's themselves. This is one of the more qualitatively appointed values, but it appears to be an appropriate way to determine the values for these areas. As mentioned earlier, Sacramento City's overall physical infrastructure and commitment to maintaining a high level of school infrastructure capability is higher than that of Palm Springs. Because of this Sacramento City was given an erosion factor of 7.5 and Palm Springs a value of 8.5 with the average value being 8.0. This means that every year Sacramento City has 7.5 school infrastructure performance capability units being eroded. The erosion factor is in units of performance units/year. So, if a school has an erosion factor of 8.0 and has 40 school infrastructure performance capability units than they have 5 years until their school is completely devoid of the ability to help their students. In order to maintain a higher level of infrastructure, a school with a high erosion factor will need to spend more money in order to keep from having a declining level of infrastructure.

One of the key factors of initial success in this model is the ***economic health percentage*** of the area. The economic health percentage represents the percentage of individuals in the area that can be considered to be economic contributors. This percentage has a large impact on the amount of funds received from local taxes and federal funds as well as the distribution of kids within the school. A high percentage represents an area that is rather affluent allowing for higher taxes and more individuals that will be considered low risk in school. The link between economic status and performance in school has been documented by many different sources (Koop, 2008). Schools that are in areas that have a low economic health percentage have a multitude of issues that other more affluent areas may not encounter.

For this model the economic health percentage of the area was determined by looking at Census data and by looking at the percentage of students that receive free or reduced priced lunches. The percentage of students that receive free or reduced priced lunches is a key indicator of the economic health of the area and is also a way for federal and local officials to gauge the economic need of a school (Ed-Data, 2008). Figure 28 below shows that both Palm Springs and Sacramento City both average around 65 percent of students receiving free or reduced priced lunches compared to an average of less than 50 percent for the state of California.


**Figure 28: Percent of Free and Reduced Lunches for Both Districts (Ed Data, 2008)**

Palm Springs shows a slightly larger percentage of those receiving free or reduced lunches so the initial economic health percentage in the model for Palm Springs is .20 while the initial economic health percentage for Sacramento City is .22 (Figure 28). These two values show that both of these areas are not very affluent and will receive more federal funds because of the increase in at risk students.

Improving the performance of at risk students is one of the main goals of No Child Left Behind. Because of this a large amount of No Child Left Behind funds go towards remedial programs such as tutoring, school choice, and other supplemental educational services. The amount of funds has an impact on how students improve, but the quality of the remedial programs is extremely important in improving student performance. ***Remedial spending quality*** is a variable in the model that helps to quantify how well remedial programs work in that area. All the funds in the world can go to remedial programs, but if they are of poor quality they will not help the students. Remedial programs that are high in quality will be able to do more with less funding, hopefully allowing more students to achieve.

The remedial spending quality for these areas was determined by looking at the reviews for tutoring and supplemental education services within the districts. This was combined with a quantitative look at the percentage of students within these districts that are actually using the remedial programs that are provided. This research determined that Palm Springs provided better than average supplemental educational services, while Sacramento City was slightly below average (CDE, 2008). These results caused me to provide Palm Springs with a remedial spending quality of 1.4 while Sacramento City had a .8 with the statewide average being 1.0.

The main way to determine the amount of money that will be received by the school is by looking at the amount of at risk pupils there are in the school. On average, at risk individuals received $1200 more per year than those not at risk (NCLB, 2002). For the purposes of this model, the amount of ***funding per at risk pupil*** was kept the same for both Sacramento City and Palm Springs. By looking at the economic health of both areas and at the amount of federal funding they receive in a year, a value that works for the model was determined.

One of the most difficult aspects of this model was keeping the federal, state, and local funding at the proper levels. Since there are so many variables that go into the amount of funding that a school or district receives it was difficult to keep the ratios around the appropriate values. For example, a large increase in funding per at risk pupil would cause the federal funding ratio to jump up higher while lowering the values for state and local funding. The statewide funding ratios for California were 8 % for federal funding, 64 % for state funding, and 28 % for local funding (Ed Data, 2008). The initial values for Sacramento City were 8 % for federal funding, 67 % for state funding, and 25 % for local funding. For Palm Springs the initial values were 8 % for federal funding, 65 % for state funding, and 26 % for local funding. These values are only the initial values meaning that these ratios are bound to change over the course of a simulation run. An increase in economic contributors would cause an increase in the percentage of local funding while decreasing the percentage of the other forms of funding.

The ***Initial School Performance*** of a school was determined by looking at past district results on standardized tests. In this model, the initial school performance is not exactly what will show up on the graph since other things such as school infrastructure and economic health go into determining school performance. The initial school performance variable helps to represent a baseline value that the districts should hope to continually be above. Both districts were provided with 25 % as their initial value for school performance, but, as it will be seen in the results, both of the districts' school performance will be influenced differently by their values for school infrastructure and economic health.

Using the main values shown earlier and other values that are contained with the model, tests were run to see how well the model represents historical results and also how well it can represent the future of the two different school districts. The results will focus on school performance, but other key success indicators such as community quality index, remedial to long term spending ratio, school infrastructure capability, and graduate to drop out ratio will also be shown. This will be followed by an explanation on why these results were received from the model and why one district achieved while the other failed.

Data was first gathered for the two districts' past performances on standardized testing. These dates range from the 2002-2003 school year, the beginning of No Child Left Behind, to the 2006-2007 school year. After gathering this data, the model was run using the values described above and seen again below (Table 4).

| | Palm Springs Unified | Sacramento City Unified |
|---|---|---|
| Initial School Infrastructure Capability | 43 | 57 |
| Capability Erosion | 8.5 | 7.5 |
| Initial Economic Health | 0.2 | 0.22 |
| Remedial Spending Quality | 1.4 | 0.8 |
| NCLB Funding per At Risk Pupil | 1300 | 1300 |
| Initial State Funding Ratio | 0.65 | 0.65 |
| Initial Federal Funding Ratio | 0.08 | 0.08 |
| Initial Local Funding Ratio | 0.26 | 0.27 |
| Initial School Performance | 0.25 | 0.25 |

**Table 4: Initial Values for Model Testing**

Using these values the following results were obtained.

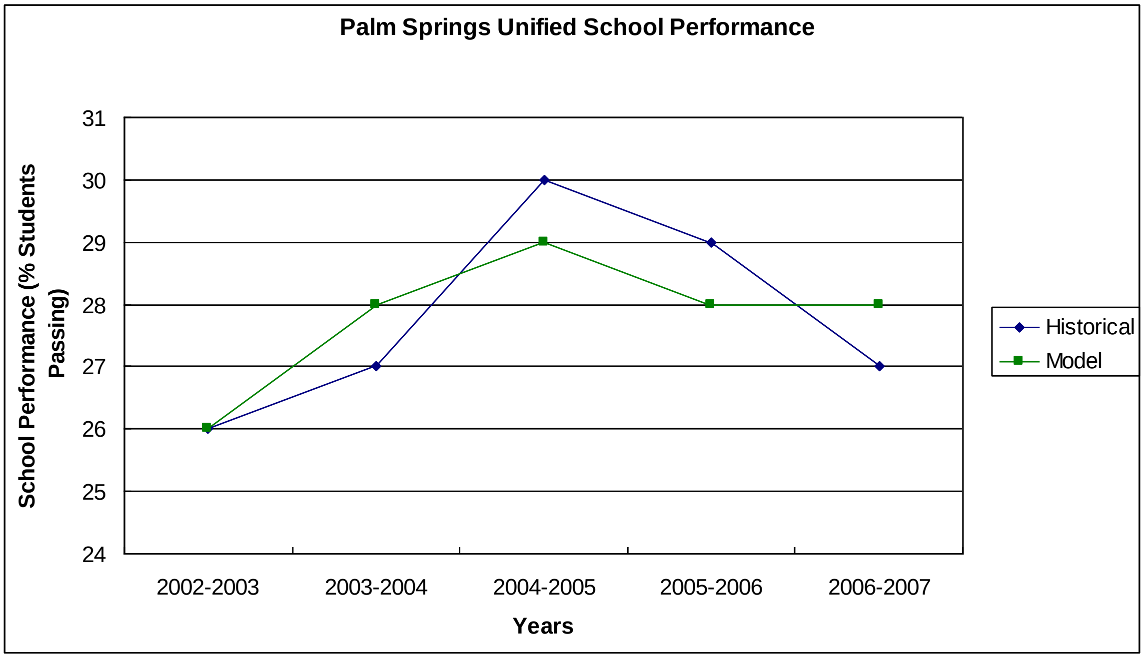


**Figure 29: Student Performance in Palm Springs - Historical vs. Model (Ed Data, 2008)**

From 2002 to 2006, Palm Springs showed an initial increase in performance and then dropped back down rather quickly (Figure 29). In the model, the performance of Palm Springs shows the same behavior, but is simply off by 1 percentage point here or there. Over time the historical and model results average 27.8 % on standardized tests.

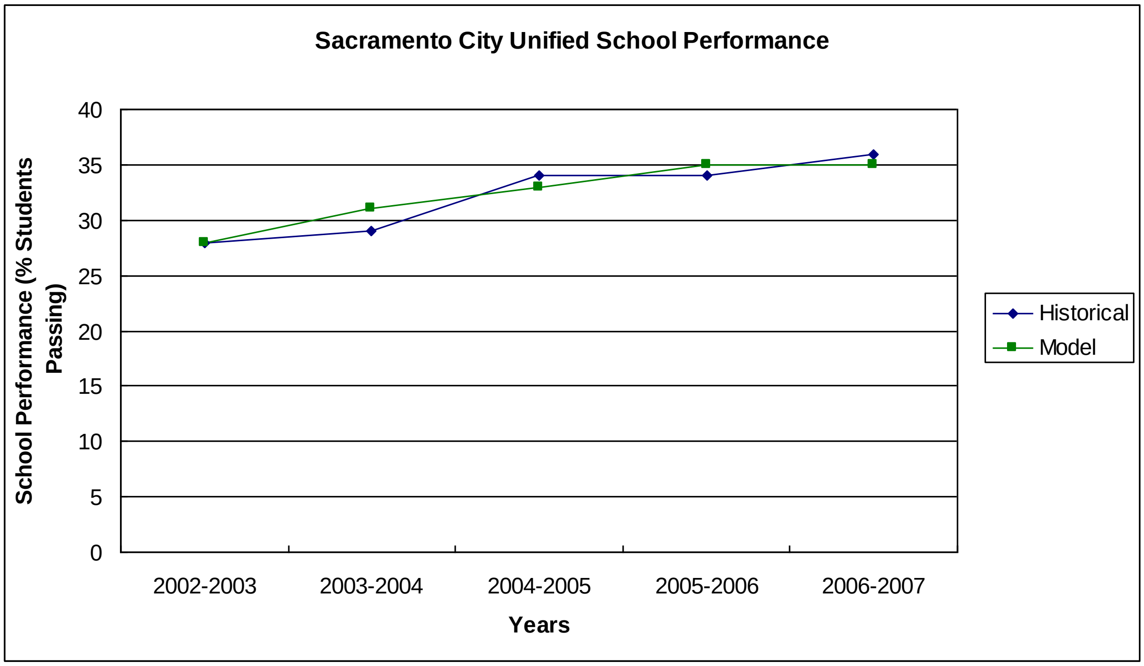


**Figure 30: Student Performance in Sacramento City - Historical vs. Model (ibid)**

Sacramento City on the other hand showed a steady increase in performance from 2002 to 2006 (Figure 30). The model showed these same results with a slightly more incremental increase. Over time the historical model averaged a 32.2 % on standardized tests and the model averaged a 32.4 % on standardized tests. So the model falls within .2 % points of the historical average.

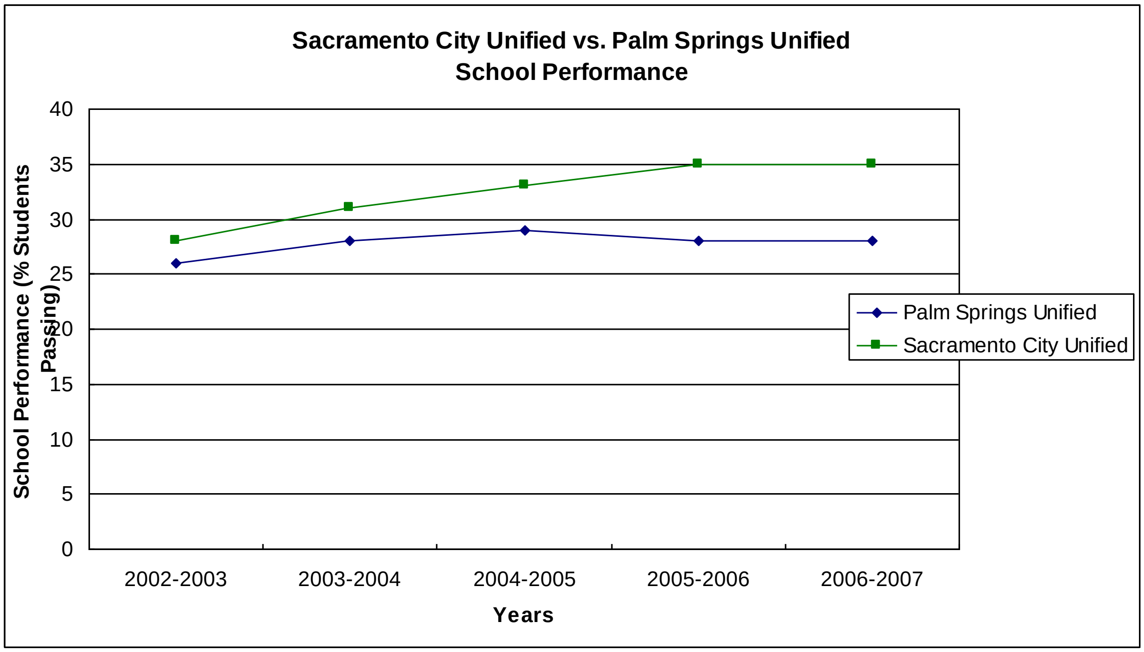


**Figure 31: Comparison of Palm Springs' and Sacramento City's Student Performance**

Figure 31 simply shows how the gap between Palm Springs and Sacramento City has grown over those five school years.

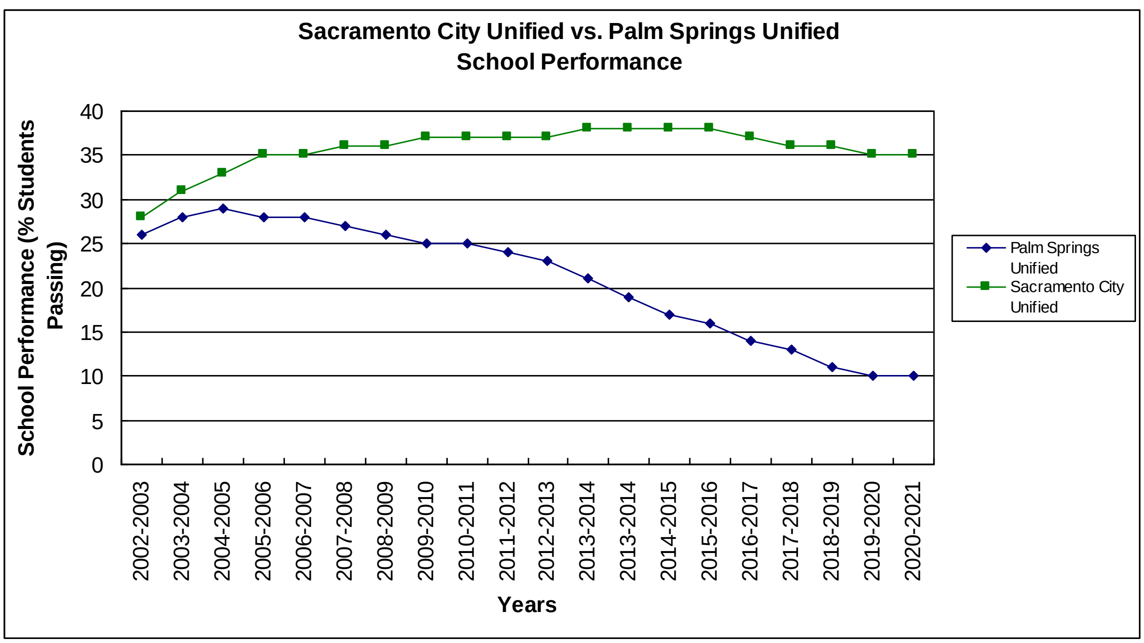


**Figure 32: Student Performance for Both Districts over a 20 year span.**

Figure 32 shows projections 15 years into the future for both Palm Springs and Sacramento City. As you can see the gap grows ever wider between the two districts with Palm Springs plummeting down and Sacramento City maintaining a higher than started level of performance. It is seen though that Sacramento City's performance does not grow very high and definitely does not reach the 100 % passing rate that NCLB wants districts to achieve by 2014. The main questions coming from this graph are why does the gap between these two districts grow wider and why does Sacramento City not continue to improve its performance level? One of the main reasons that some schools succeed while others fail is the fact that the school infrastructure capability is so integral in improving student performance. Maintaining the school infrastructure is key in succeeding over a course of time. Figure 33 below shows the difference between the school infrastructures of Palm Springs and Sacramento City. As you can see Palm Springs' infrastructure drops sharply while Sacramento City's infrastructure begins to drop, but at a less rapid rate.

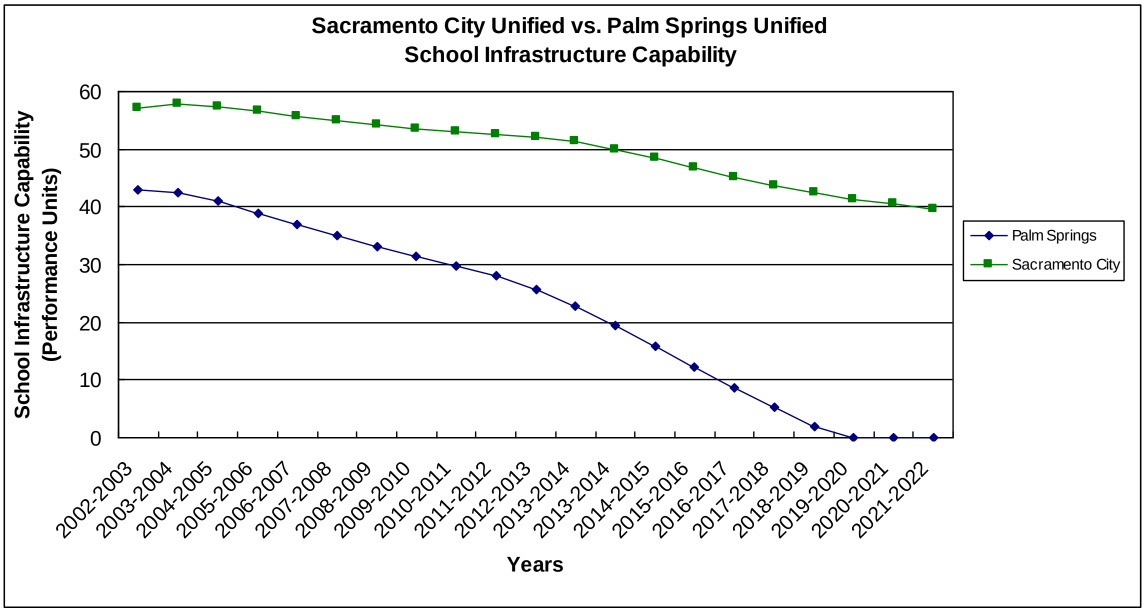


**Figure 33: Comparison of School Infrastructure Capability over a 20 year span.**

This change in school infrastructure can be attributed to the erosion factor and to a commitment to remedial programs as opposed to long term improvement (Figure 33). The difference in erosion factor has been discussed already. If the erosion factor is low, like Sacramento City, not as much money is needed for improving school infrastructure. A low erosion factor helps to stimulate growth or at the least lessen the decline in school infrastructure. The remedial to long term spending ratio is also very important. Figure 34 shows how both districts' commitment to remedial spending grows over the years causing a decrease in school infrastructure capability.

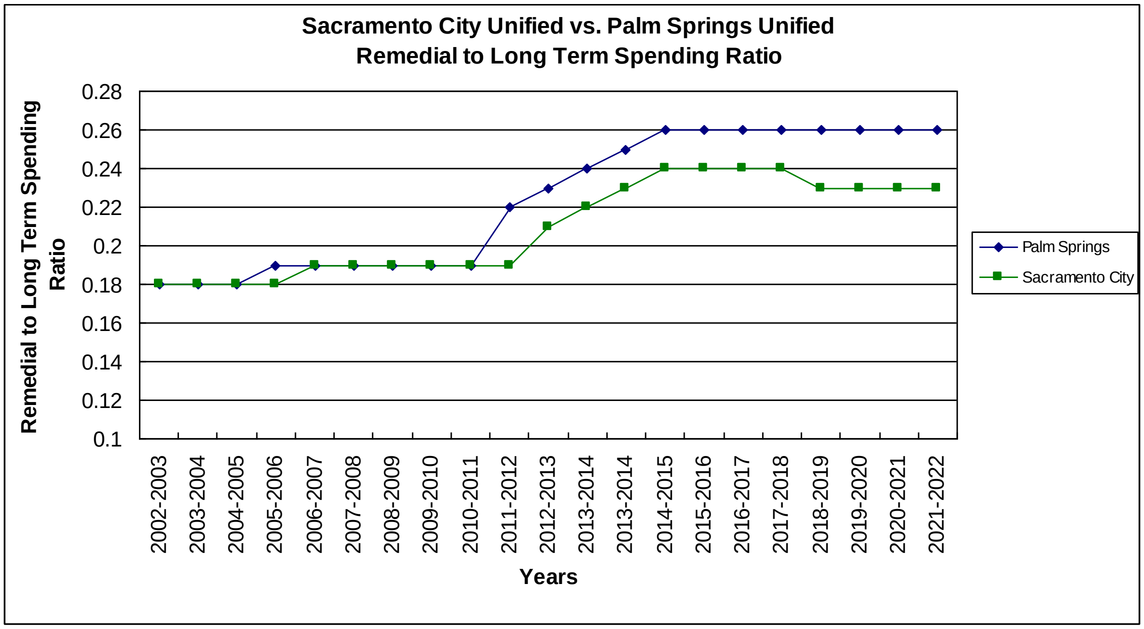


**Figure 34: Comparison of Remedial to Long Term Spending over a 20 year span.**

It costs a large amount of money to draw in high quality teachers, bring in new technology, and to maintain school facilities. This change in spending is caused by No Child Left Behind. As either of the districts begins to not reach adequate yearly progress, they have to allocate more money towards remedial programs. Of course, if a larger percentage begins to go towards remedial programs instead of long term improvement the school infrastructure will begin to falter. If you compare the two previous graphs you can see that as the remedial to long term spending ratio gets higher, the rate of decline in school infrastructure increases (Figures 33 and 34).

The following figures (Figures 35 and 36) help to illustrate the importance of school infrastructure on achievement. Figure 35 shows how Palm Springs would behave at school infrastructure levels of 0, 20, 40, 60, 80, and 100. Figure 36 shows Sacramento City at those same levels. As you can see, raising infrastructure capability causes a large increase in student performance.

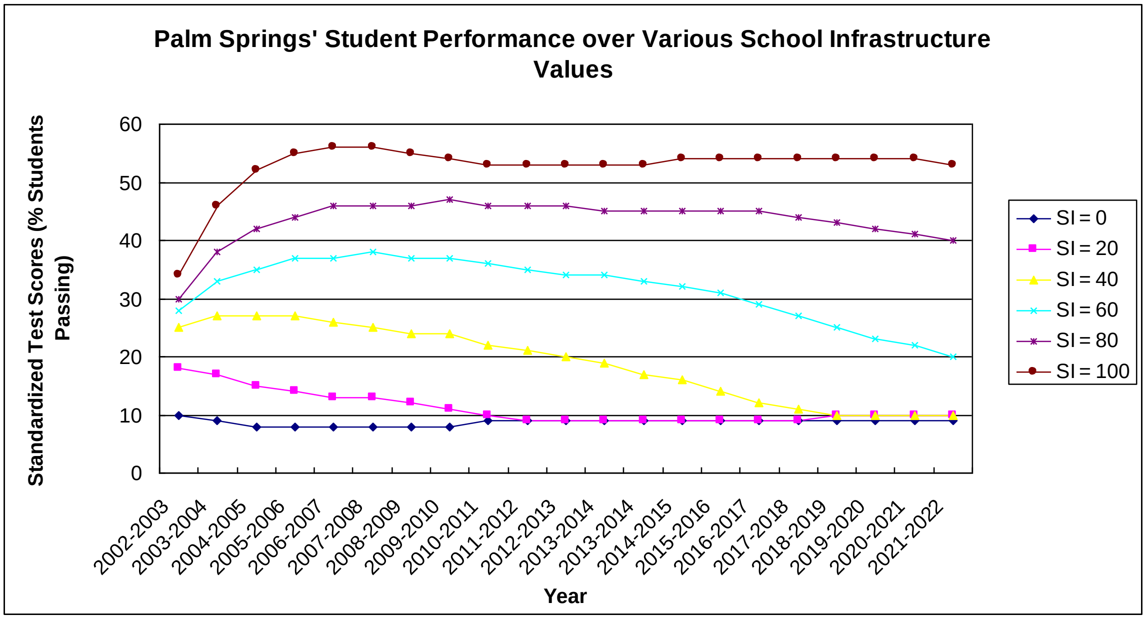


**Figure 35: Impact of Increasing School Infrastructure has on Student Performance in Palm Springs**

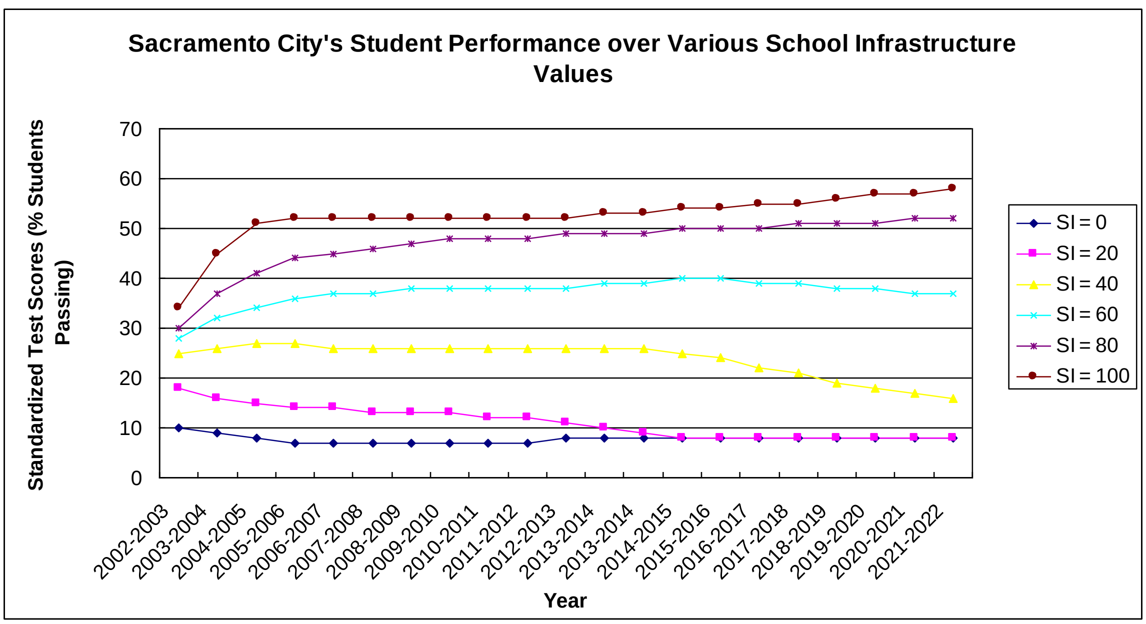


**Figure 36: Impact of Increasing School Infrastructure has on Student Performance in Sacramento City**

These images help to show how important a commitment to building a long term infrastructure is to a school.   Providing high quality teachers, a focus on individual student attention, providing technology, and establishing a healthy physical learning environment are all keys in improving student performance.  Increased remedial spending can work in the short term, but over time it fails to solve a school's underlying issues.  In the Figure 37, the remedial spending quality was drastically increased starting with year 5.

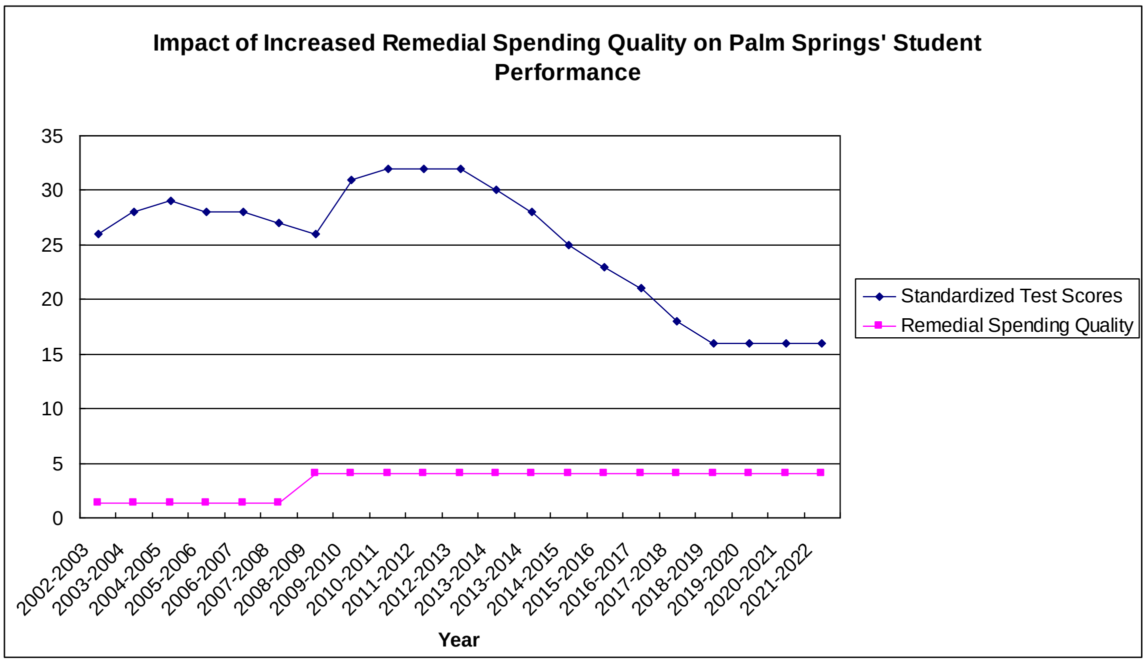


**Figure 37:  Impact of the Increase in Remedial Spending Quality has on Student Performance**

As you can see, raising the remedial spending quality only helps student performance for a short period of time before it again begins to fail (Figure 37).  This is because the fundamental problems in the school are not taken care of and are actually pushed to the side in lieu of short term fixes.  Other principal factors are involved in affecting student performance.

Although school infrastructure is the main factor in determining student performance, there are other factors outside of the school that impact the way students perform within the school. One of the main variables that impact student performance is the community quality index. The community quality index is a combination of the economic health of an area and the school quality. It is impacted over time by the performance of students on standardized tests as well as the drop out and graduation rates of students. A large number of economic contributors will allow for a higher community quality index. The community quality index has a major impact on the movement of individuals into and out of the community. A high community quality index will cause more economic contributors and their families to want to move into the area. Over time this movement will cause high achieving children to be born and then enter into the schools, thereby improving the overall performance within the schools. The change in community quality index is slow, but an overall increase will help to further changes in student performance. Figure 38 shows the change in community quality index for both districts over time.

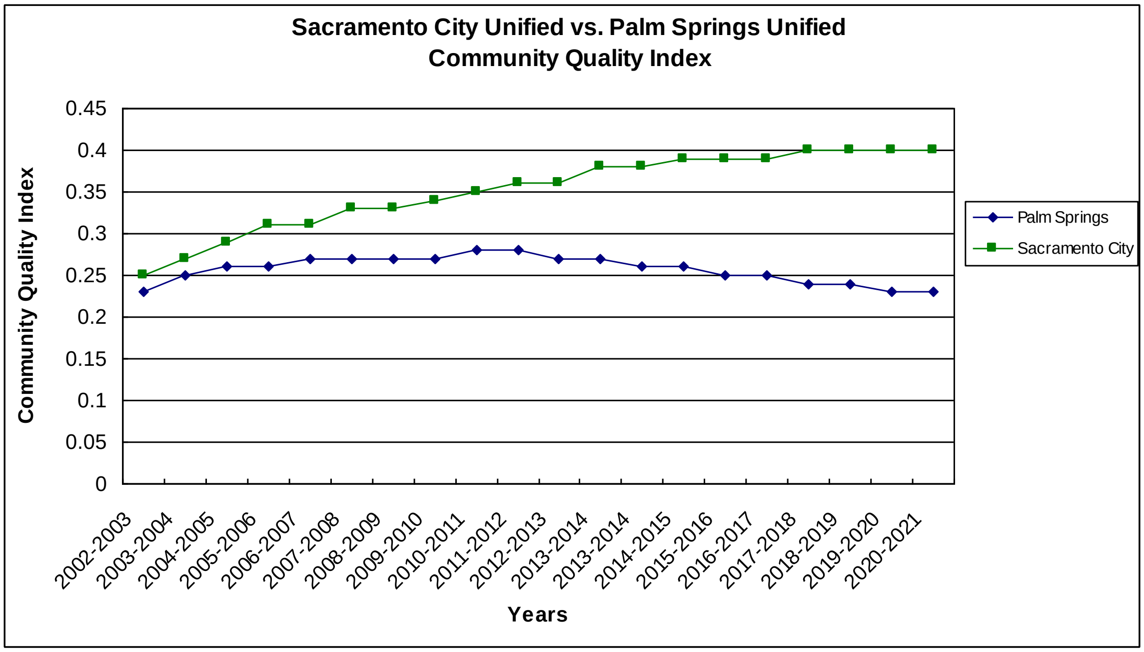


**Figure 38: Comparison of the Community Quality Index for Both Districts**

Since Sacramento City was able to maintain an increased level of performance their community quality index has slowly increased (Figure 38). The opposite is true for Palm Springs where their performance decreased along with their community quality index. Sacramento City's ability to improve community quality index helped them to be able to bring in better students and also to retain the higher performing students. This improvement high community quality index helped to keep student performance from dropping in Sacramento City in spite of the declining school infrastructure. One important note is that the community quality index is not a variable that will grow or drop quickly. It is something that takes a lot of time to show large changes. This shows the importance of realizing that there are factors both in and outside of the school that impact student performance.

Another area in which in school and out of school factors interact is the graduation and drop out rates. In this model the ratio of graduates to drop outs was tracked. This ratio is impacted by the number of high risk and low risk individuals within the school. If this number is high, the economic health and community quality of the area will increase since graduates become economic contributors. A low graduate to drop out ratio would mean that more economic detractors are entering the system, causing a decrease in economic health and community quality. Figure 39 looks at the graduate to drop out ratio for both districts.

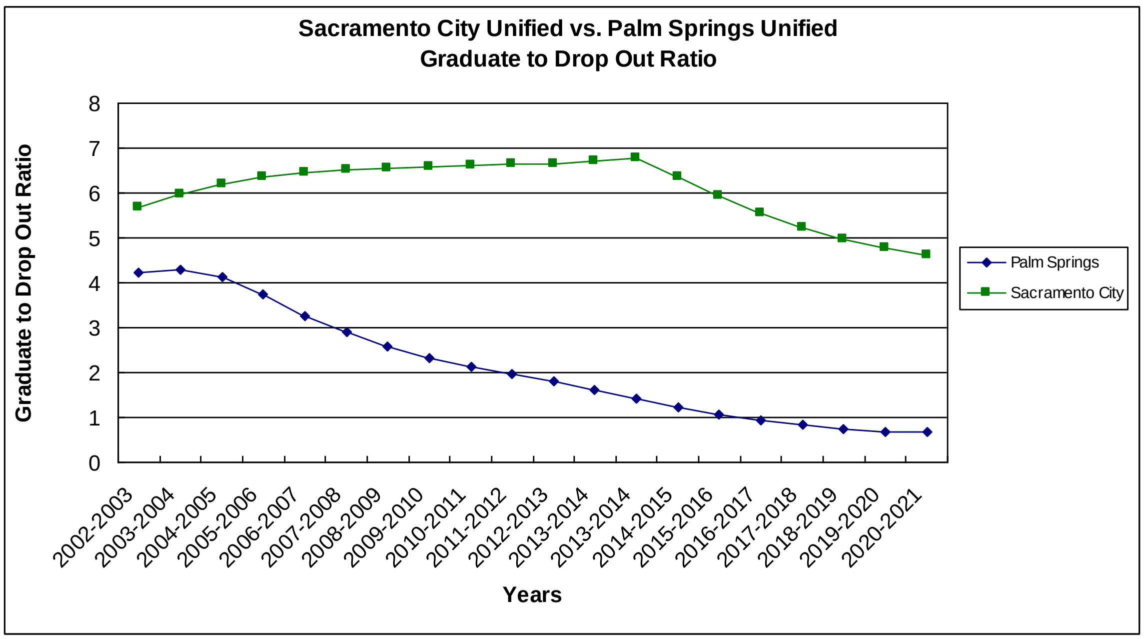


**Figure 39: Comparison of Graduate to Drop Out Ratios for Both Districts**

Figure 39 represents much of what has already been seen with the other results. Over time Palm Springs has shown a large decrease with about half of the students dropping out and only half graduating. Sacramento City has shown a decrease over time, but is not yet represented in the community quality index since their school performance has been consistent over the years. It is possible that over time Sacramento City will also show a dip in community quality.

As the section above showed the main reasons that determine why two schools with similar demographics can show very different results over time are the quality of school infrastructure, the erosion factor, the remedial to long term spending ratio, and the community quality index. As both of these schools begin to fail to reach NCLB standards, Sacramento City is able to keep a consistent level of performance even though they are forced to spend more money on remedial programs. They can achieve this due to a commitment to school infrastructure. Palm Springs on the other hand continues to have student performance decline since they are unable to maintain a quality school infrastructure. For Palm Springs the cycle of failure continues to occur. As students fail and drop out they enter the community and lower the community quality index which in turn affects the quality of the schools. No Child Left Behind's insistence on short term programs handicaps those schools that really need a boost in school infrastructure.

Such things as economic health, initial school performance, and funding per student, among other things, are also key factors in determining the success of a school, but these things are kept nearly the same for both districts. The following section will look at the impact of changing the amount of people participating in school choice, the initial economic health, and the initial passing rates for low achievers.

***Model Experiments***

This section will go beyond the case studies and run experiments that will help to show the impact of other variables that were not looked at within the case studies. Only one value will generally be changed from experiment to experiment, but it will be valuable to see the impact that these changes have.

The first experiment will look at how an increase in those participating in school choice will change student performance. At the moment school choice is not used that often, but as No Child Left Behind begins to get older school choice may be chosen more often. How does that movement of students into and out of schools impact student performance?

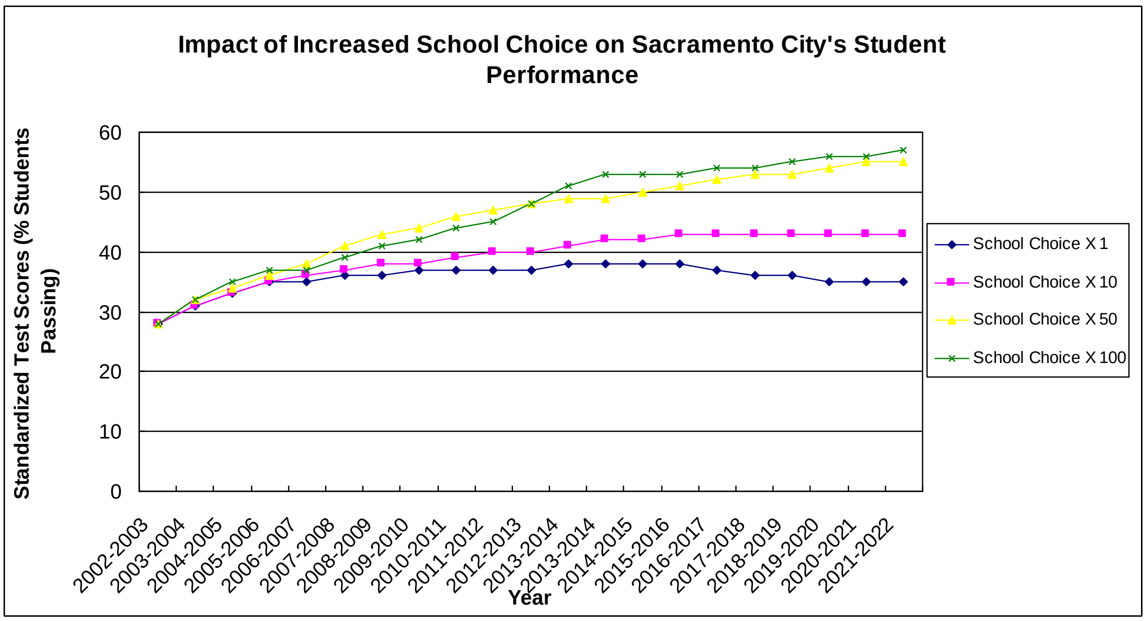


**Figure 40: Impact of Increase School Choice on Student Performance in Sacramento City**

Figure 40 shows that if school choice became more prevalent a quality school would increase their performance capability. The amount of school choice going on was multiplied by 1, 10, 50, and 100 and the results show an increase in student performance at each increment. Logically, this makes sense as a quality school would be able to keep the students they have and then draw in low risk students from poorer performing areas.

School choice could also provide a way to rid a school of its poorer performing students by allowing them to switch to another school.

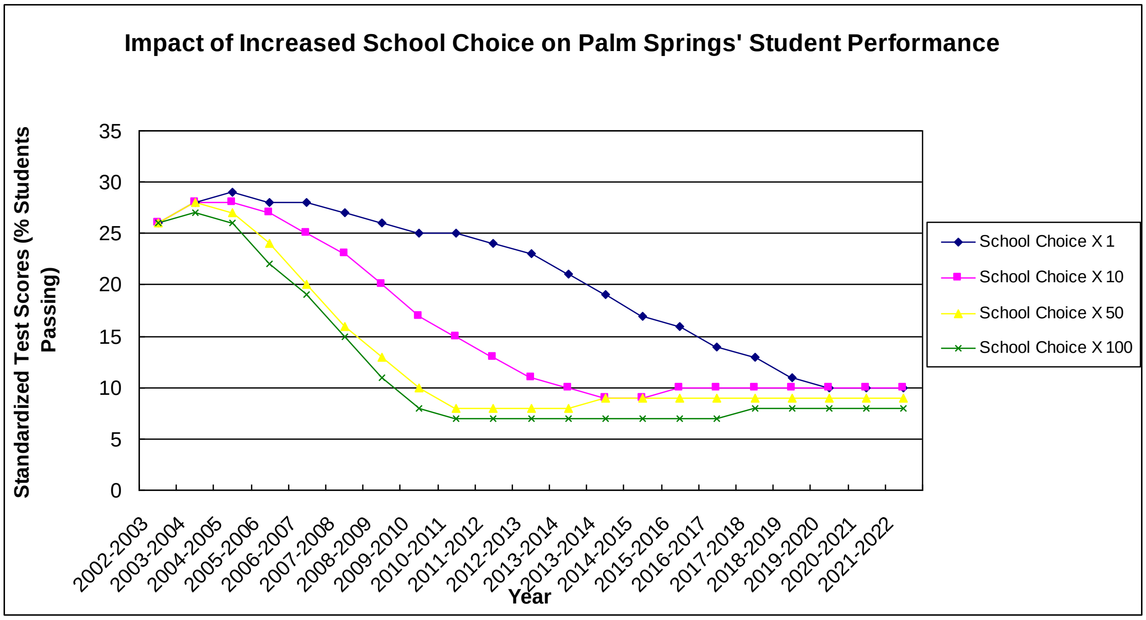


**Figure 41: Impact of School Choice on Poor Performing Schools**

Figure 41 shows the opposite effect where school choice impacts poor performing schools in a negative way. This shows that low risk students at poor performing schools will leave those schools in search of better ones. This leaves a larger percentage of high risk students behind. As you can see, school choice is a good idea for a school that is showing decent results, but for those schools already behind it is just another obstacle that they must overcome.

The second experiment looks at the importance of the economic health of an area. The economic health helps to determine the makeup of a school as well as the community quality index. Some areas that have less money are automatically put into a bit of a hole as compared to those who have a large amount of money available.  How big is the impact of economic health and can it be overcome?

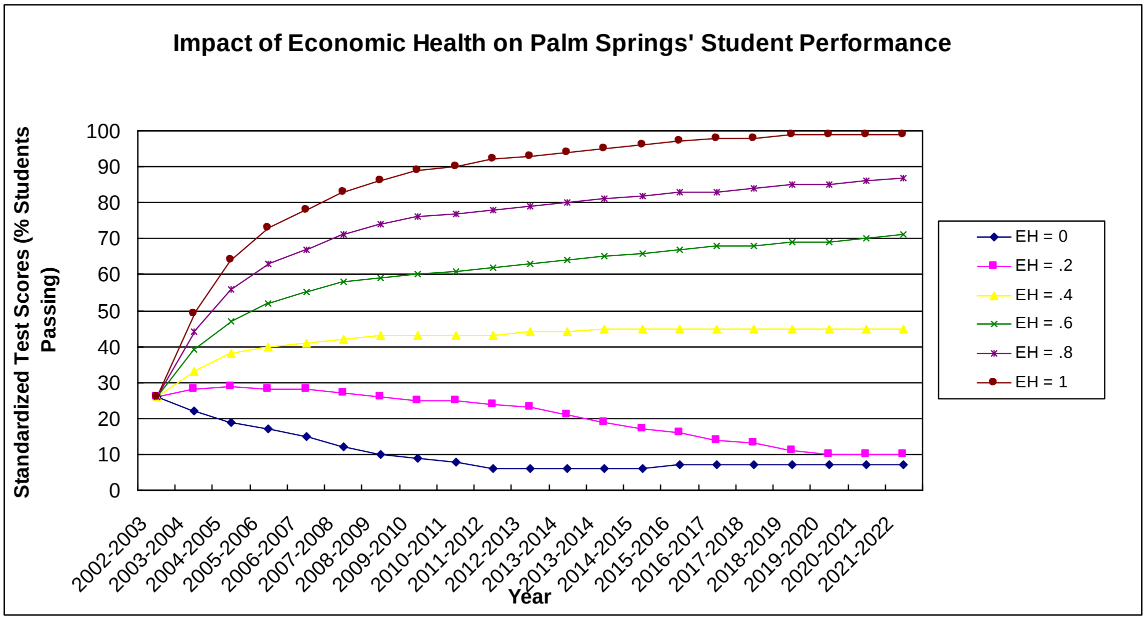


**Figure 42:  The Impact of Economic Health on Student Performance**

Figure 42 shows a range of economic health values from 0 to 1 going up in increments of .2.  As this figure shows the economic health of an area goes a long way in determining how well students will do.  A high economic health index means that there are more economic contributors which lead to more local taxes that can go towards increasing the school infrastructure capability.  This also influences the amount of low and high risk students entering into the school as well as the attractiveness of the area to outside families.  An area low economic health index has to overcome the obstacles of not having these advantages and with No Child Left Behind, a school that does not reach adequate yearly progress is further restricted from doing what they want with the little amount of funding that they have.  One of the main ways to improve a school or district's standing is through infrastructure improvement, but many of these areas simply do not have the money to make these improvements.

The third experiment looks at how changing the passing rate of low achievers would impact student performance. For the other tests an initial passing rate for low achievers was set rather low, but how can raising these passing rates affect student performance?

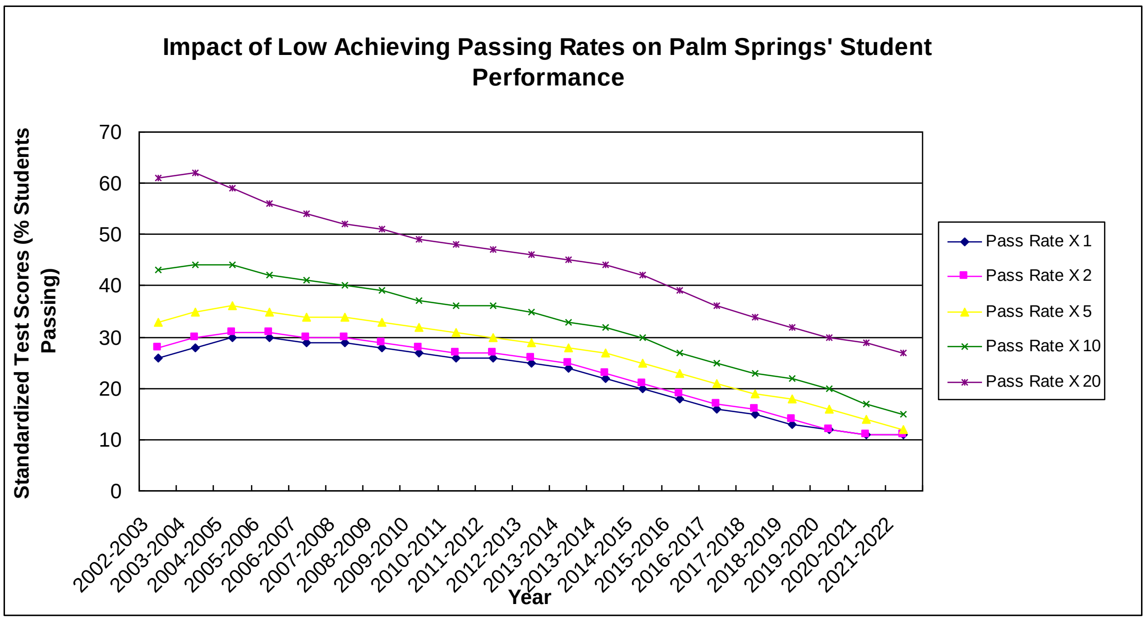


**Figure 43: Impact of Changing the Low Achievement Pass Rate on Student Performance**

Figure 43 above is straightforward in showing that improvements in the passing rates of low achievers would definitely improve overall student performance. Although it also shows that over time student performance will still slowly decrease because it takes more than just raising the low achieving pass rate.

One of the major issues with NCLB and pretty much any piece of policy is funding.  Many have complained that NCLB is under funded and therefore cannot complete its intended tasks.  Figure 44 shows how funding for NCLB impacts student performance.

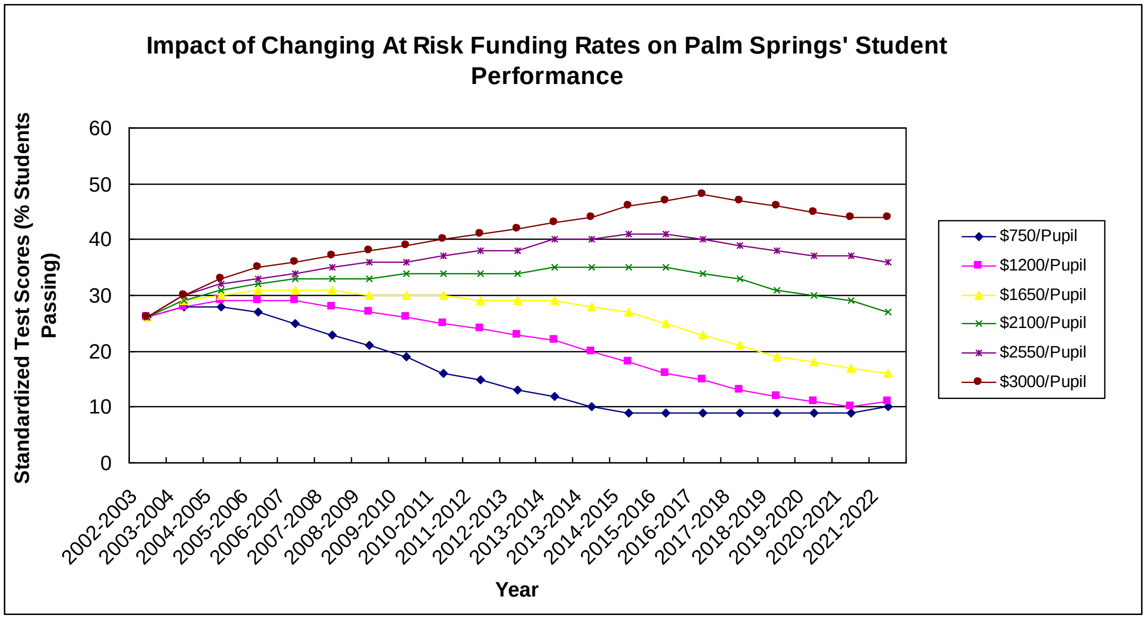


**Figure 44:  Impact of Changing NCLB Funding has on Student Performance**

As this Figure 44 shows, an under funded school will fail and fail rather quickly. A school without proper funds will not be able to provide quality remedial programs or long term development programs.  Schools that at or above proper funding levels will be able to improve student performance or at least make a better attempt at improving their school.  The graph shows that an excess of funding improves student performance, but not too extensively.  Again, it is under funding that causes a large amount of problems.

The following chapter will discuss these results and provide possible changes that could be made to make No Child Left Behind more effective.

## Chapter 5: Discussion – Policy Implications

The previous chapter looked at some of the main reasons why certain schools succeed and why others fail under No Child Left Behind. The quality of school infrastructure and its upkeep, the remedial to long term spending ratio, the community quality index, and funding are all main factors involved in the success or failure of a school. Many other factors go into student performance, but these appear to be the most important. Now that the important issues have been determined, this thesis will provide some suggestions on how No Child Left Behind could be altered and used to achieve the admirable goals it set forth when it was enacted. With some small changes No Child Left Behind will be able to better handle poor performing schools. This chapter will look at some of these small changes individually and then at how a combination of these changes will improve student performance.

A main issue that many individuals see with No Child Left Behind is the strict adequate yearly progress requirement. The requirements are rather lax to start, but they become harder and harder to achieve as time goes on. No Child Left Behind has these strict requirements in order to have a 100 percent passing rate by 2014. As is seen in earlier examples, schools are going to have a very tough time making this milestone. A more relaxed adequate yearly progress requirement will allow schools to slowly improve their student performance and could possibly reach 100 percent passing by around 2030. Instead of a sharp rise in required performance, the modified required percentage moves up in small increments every year. This will keep schools out of program improvement and will allow them to spend funds on long term development. Figure 45 shows results from the model for Sacramento City with the current required pass rate and with the modified pass rate.

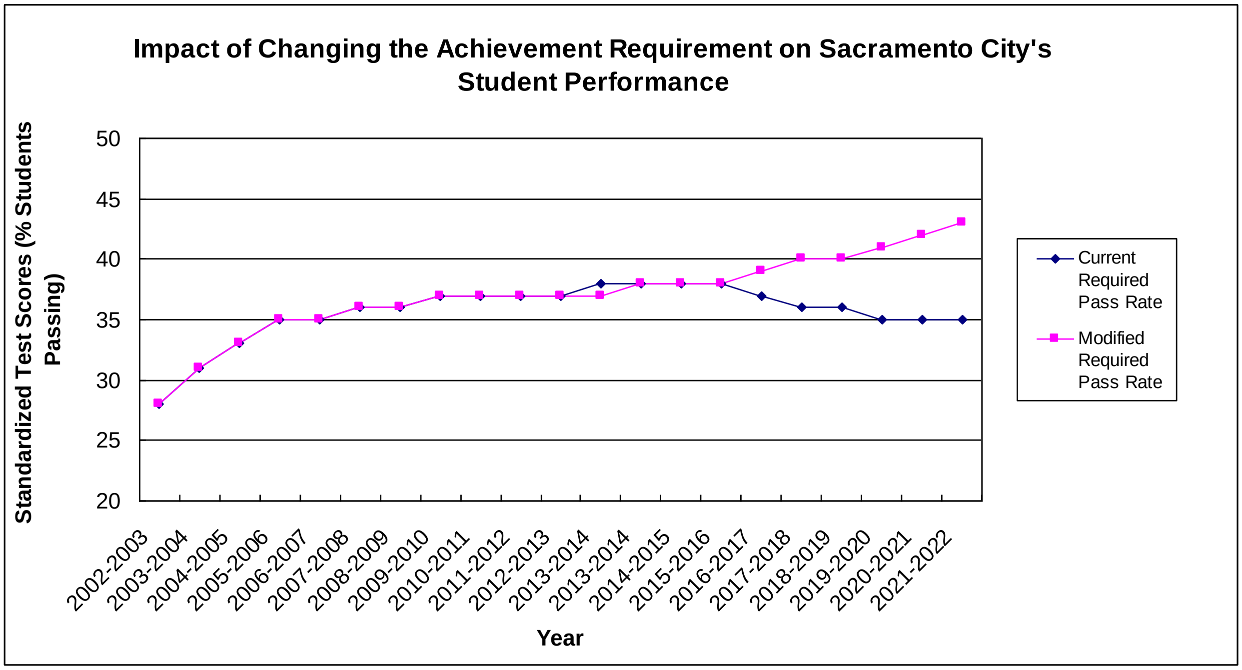


**Figure 45: Impact of a Changing Achievement Requirement on Student Performance**

Figure 45 shows that both of the rates allow for growth in the first few years, but when Sacramento City would normally fall under the pressure of program improvement with the current requirement they are able to continue to improve with the modified requirement. Legislation is currently being discussed that would help to relax the current No Child Left Behind requirement and this appears to be a smart move.

The previous chapter discussed the impact of funding on student performance. In that example a rather large increase in funding was used to show the importance, but even relatively small increases in funds could help to improve No Child Left Behind and student performance. Figure 46 shows the impact of changing the amount of NCLB funding on student performance in Palm Springs.

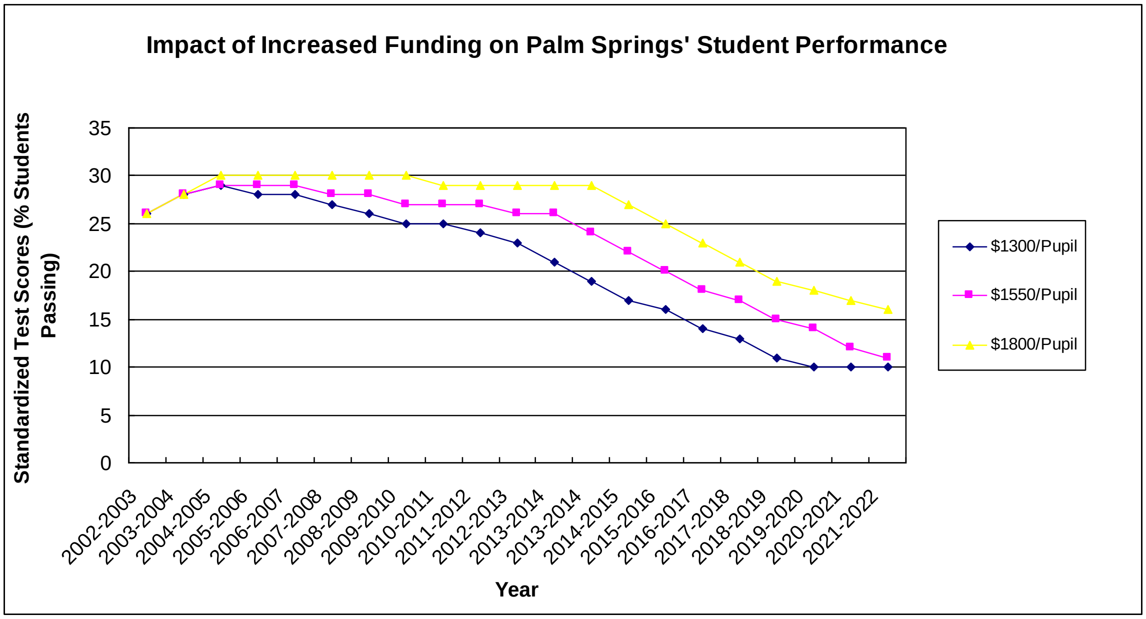


**Figure 46: Impact of Increased NCLB Funding on Student Performance**

For Figure 46, 1300 dollars per at risk pupil was used and then increased by 250 and 500 dollars. As you can see a raise in the amount in funding does not postpone the inevitable failure, but it does help to postpone and soften the fall. Extra funding will allow schools to spread the money around and to better provide students with the tools they need to succeed.

Another main issue that arises within the model is the amount of funding that is spent on remedial programs instead of on long term programs. This problem is exacerbated as a school begins to fail and has to put more and more federal funds towards remedial programs. In order to allow more flexibility for a failing school, the amount of funds that must go to remedial programs should be cut in half. Cutting the amount of funds towards remedial programs in half will allow schools that continue to fail to have money for remedial programs, but it will not handcuff them financially as much as they currently are. The following figures show both Sacramento City and Palm Springs and how cutting the amount of federal funds that go towards remedial funds impacts student performance.

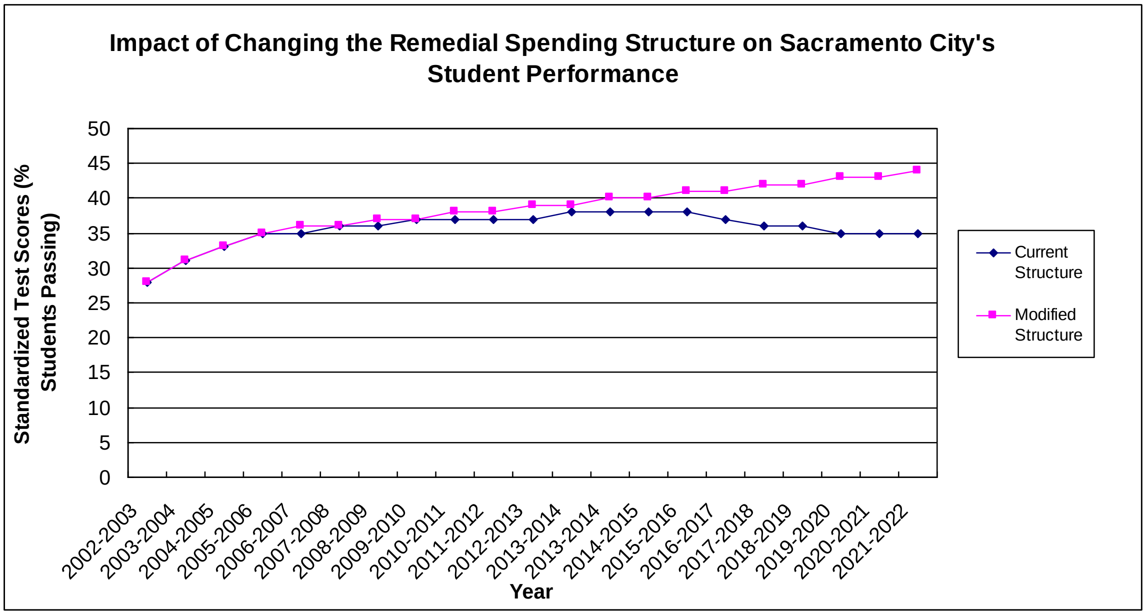


**Figure 47: Impact of Changing Remedial Spending Structure on Student Performance in Sacramento City**

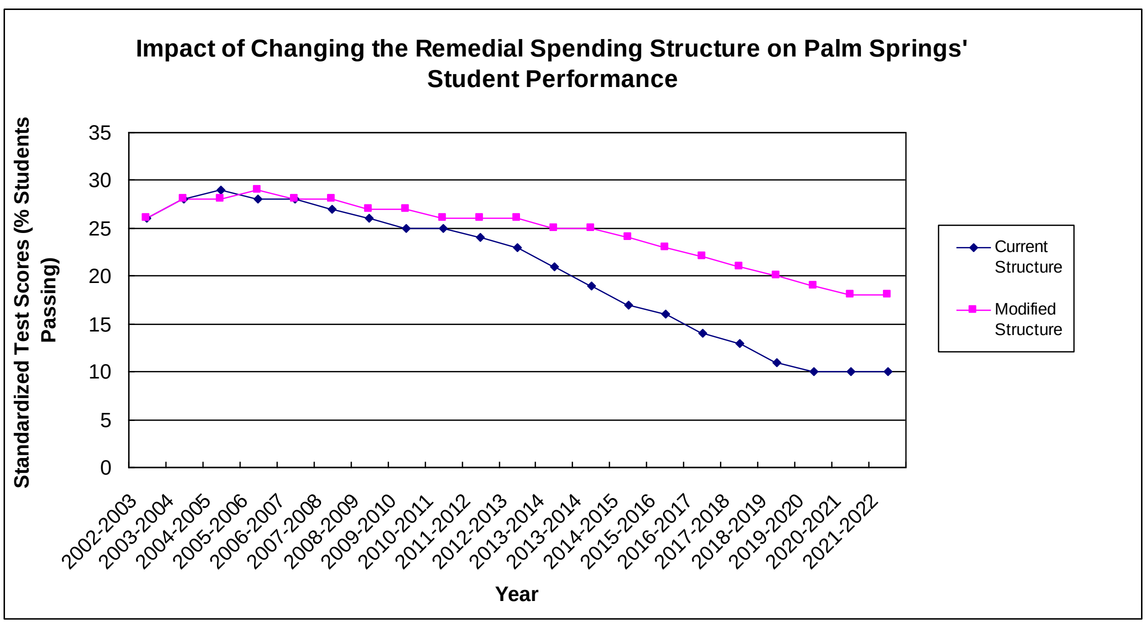


**Figure 48: Impact of Changing Remedial Spending Structure on Student Performance in Palm Springs**

Both Figures 47 and 48 show that this change in policy would help to improve student performance over time, even if it is not a drastic change. As it is seen in the second figure, this change could possibly keep schools from improving as fast since they will not have as much money for remedial programs, but over time this change proves to be quite beneficial.

The final change that is suggested would be a more extensive look at infrastructure development and maintenance. NCLB does have provisions for quality teachers, technology, and healthy facilities, but it is important to extend this farther in order to encompass infrastructure maintenance over a long period of time. This would help to lower the erosion factor over time which would help poor performing schools to increase their infrastructure's capability. The following figures looks at both Sacramento City and Palm Springs and how lowering the erosion factor by 1 would impact student performance.

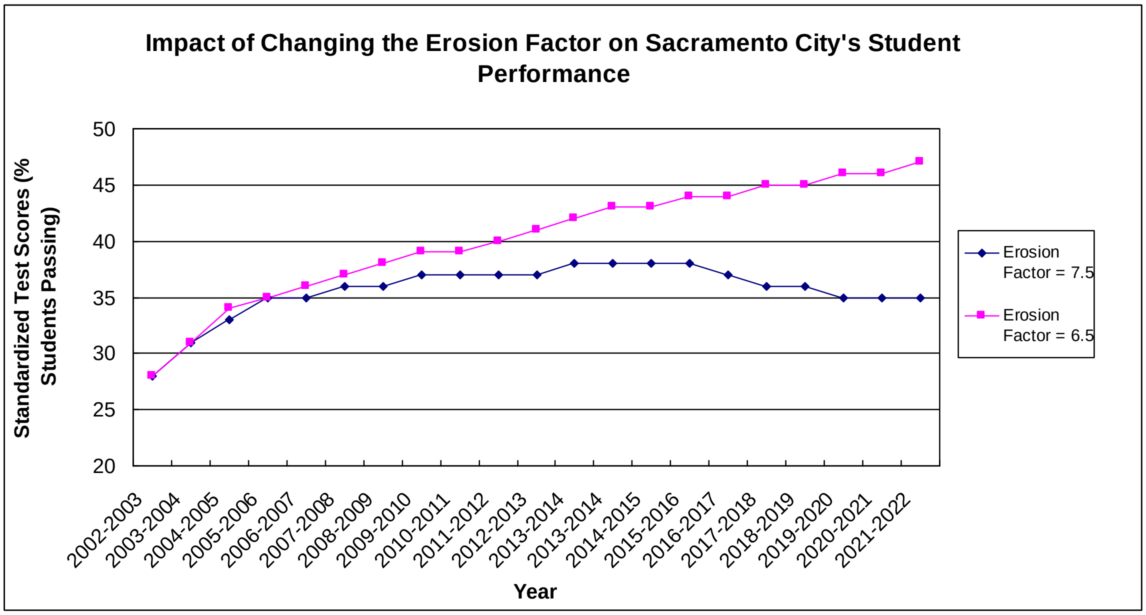


**Figure 49: Impact of Changing Erosion Factor on Student Performance in Sacramento City**

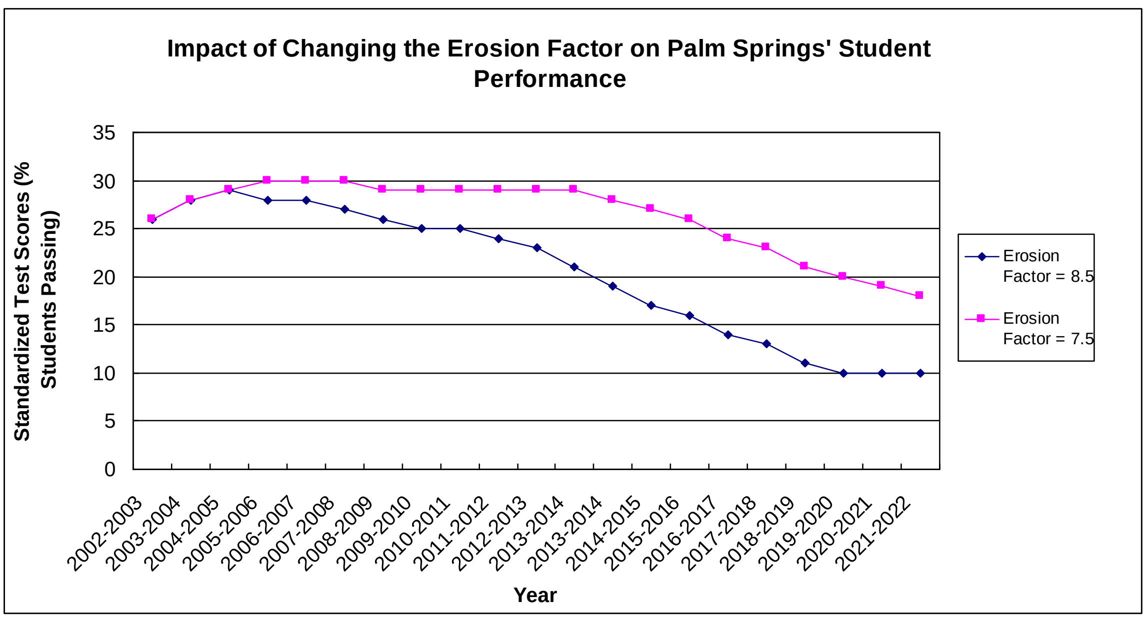


**Figure 50: Impact of Changing Erosion Factor on Student Performance in Palm Springs**

The changes to the erosion factor help both of these schools to maintain their infrastructure and to keep their level of performance at a higher level than normal (Figures 49 and 50). It still does not help Palm Springs to become a successful school, but like some of the other options it does help to soften the blow, hopefully providing more time for the district to recover.

Of course there is not just one simple answer on how No Child Left Behind could be improved to help more students and schools. The answer will lie in a combination of changes. It is seen above that Palm Springs continues to fail despite the changes that were proposed. The decline in student performance is slowed, but the district fails nonetheless. Figure 51 shows how a combination of all of the above changes helps Palm Springs to improve their student performance.

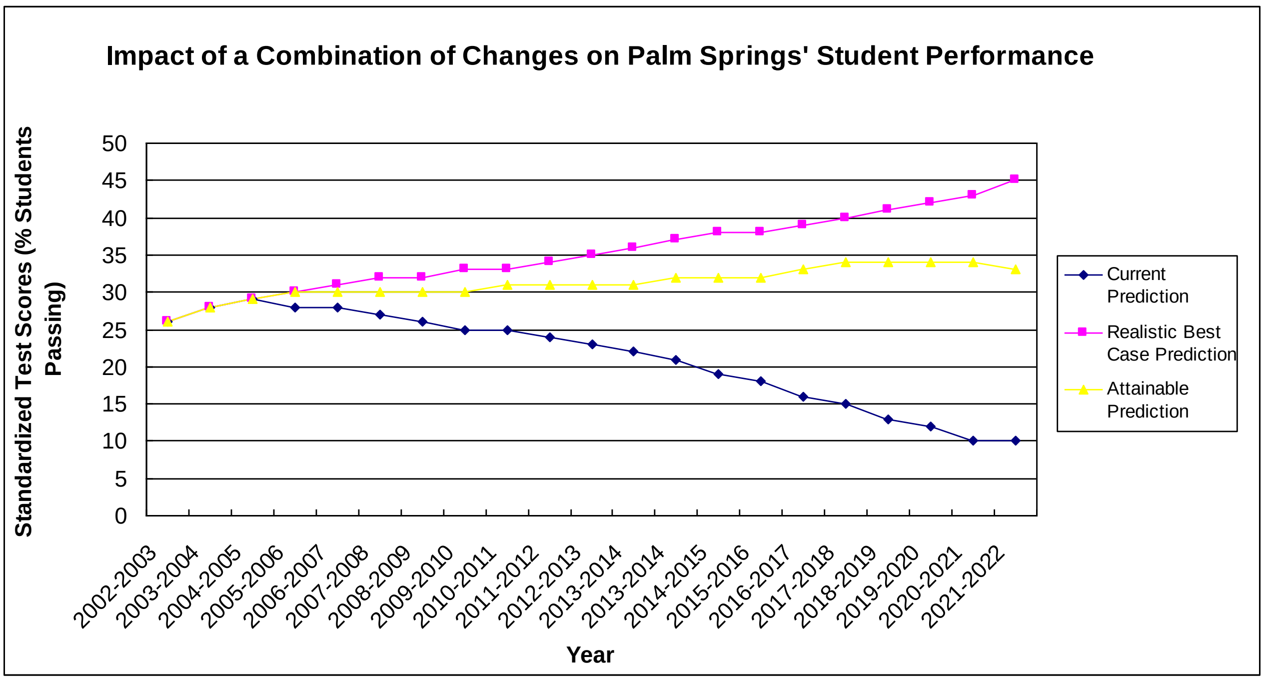


**Figure 51: Impact of a Combination of Changes on Student Performance in Palm Springs**

Figure 51 shows three different combinations of changes. The line that shows the poorest performance is under the current values. The line that shows the greatest performance value decreases the erosion factor by 1, increases the funding per at risk pupil by 250 dollars, uses the modified adequate yearly progress requirement, and cuts remedial spending of federal funding in half. The middle line shows a more attainable combination of values. The funding per pupil and adequate yearly progress is the same as the top performing line, but the remedial spending is not cut by as much and the erosion factor is only decreased by .5. It is interesting to see how these changes can combine to help make a failing school into a successful school. Of course if funding per at risk pupil was increased by 2000 dollars and the erosion factor decreased by 5 the performance would be even greater, but it is important to suggest changes that are feasible. Ideas could also be suggested to improve the economic health of an area or the community quality index but that does not fall within the realm of No Child Left Behind or within the realm of this paper. Hopefully the suggestions made in this thesis to improve No Child Left Behind will impact the economic health and community quality as well as the overall school environment.

## Chapter 6: Restrictions, Assumptions, and Future Uses of the Model

Now that some options have been provided for how to change No Child Left Behind using the model it is important to look at how this model should be used and how it can be improved. This chapter will also look at some assumptions that were necessary in order to create this model.

### *Restrictions*

For a model to be successful it needs to be used for the right situations. A model is void if it is used improperly. One of the main restrictions placed on this model is that it should not be used as an indicator of the economic health of an area. This model employs research to handle the economic piece of the model, but it would take much more research to understand the incredibly complex relationships between education and economics. Another restriction of the model is seen within most other models and that is that this model cannot possibly encapsulate every variable or factor that occurs in a real world situation. This model cannot account for a terrorist attack on the school or other rare events. This thesis attempted to encapsulate many variables into the school infrastructure capability stock, but that cannot be used to represent every variable that occurs in the real world. Another main restriction on the model occurs because of issues with the magnitude of certain variables. Curious things begin to happen when the funding sector begins to have incredibly large increases. The model suggests default values and for many variables if the value inputted by the user is extreme, the model will exhibit behavior that will not be useful for the user to study. Again, this is another restriction that has to do with time. It would be very difficult to account for all variables and their maximum and minimum values. The model does handle values that are currently seen in the real world well, it is just future possible values that could cause problems. The final restriction placed on the model is that it is currently set up for use for a researcher with system dynamics and educational dynamics experience. There is not currently a user interface in place that would explain and help an educational administrator to use the model and work with Stella. As it is, any answers that need to be answered would have to go through someone with Stella experience and someone that has knowledge of the model.

***Assumptions***

As stated before certain things to be done in order to save time and to simplify the model. Because of this, many assumptions needed to be made to create a complete model. These assumptions can generally be seen as best estimates based off of research. Many of the values needed to be assumed because know actual value exists in the real world. Some of these assumptions and the reasoning behind their values were described earlier. Such things as school infrastructure capability, capability erosion, remedial spending quality, initial economic health, and community quality index were all variables where arbitrary values need to be applied. Other variables that were treated in this same way were the variables that showed the impact of school infrastructure, remedial spending, and community quality index on various aspects of the model. School infrastructure capability has an impact on the academic improvement and decrease of both high and low risk students. It was a logical assumption to show that a high school infrastructure capability would increase the performance of low risk students and a low school infrastructure capability would decrease the performance. The same could be said for the variables for the impact of infrastructure capability on the passing rates of low and high achievers. The impact of remedial spending was seen on the high risk students. A high level of remedial spending combined with a high remedial spending quality was assumed to cause a good increase in the performance level of poor performing students. An attempt was made to ensure that the impact was less than that of the school infrastructure, since the school infrastructure has a larger influence on student performance. Finally, the community quality index has a large impact on the movement of families in and out of the area. The value for this variable was difficult to attain, but to find it research was conducted on the movement in and out of many districts. Using these numbers an estimate of the values that should be used for high, low, and average community quality index values was determined. Again, these numbers may not be perfect, but without real values these best guesses are the best that are available.

Some other basic assumptions were made throughout the model. One assumption that was made for the sake of simplicity was simply creating two groups; low risk and high risk. Creating more than two groups would create exponentially more links and dynamic relationships which would have created a much more complex model. For times sake the model retained the two group system even though a three or more group model would be more realistic. An assumption was also made that within the model that those who drop out would become economic detractors and those that graduated would be economic contributors. Obviously not everyone who graduates succeeds in finding a job and contributing and not every drop out becomes an economic detractor, but for the sake of the model a decision was made that these instances would even out and could be ignored within the model. Much of the other assumptions in the paper having to do with funding or school infrastructure can be changed via the user interface, so their values depend upon the user's discretion.

***Future Uses and Improvements***

With the creation of this model it can now be seen where it could use some improvement and also where someone could take the model in the future. One of the first improvements that could be made would be to create a user interface for the model that teachers and administrators would be able to use. A desktop model where the user could first learn the basics of Stella, receive an explanation of the dynamics of the model, and then learn how to change and experiment with values for the model would be a great way to receive feedback. Having individuals in the educational environment experiment with the model would help to increase the quality and depth of the model. This could also lead to this model becoming commercially available to schools and school districts as a way to evaluate and predict the impact of certain policies or events.

As far the model itself goes, the school infrastructure capability stock could be improved to encapsulate more aspects of school infrastructure. Such things as violence in the school, the quality of school books, and many other factors could be added into school infrastructure in order for it to represent the actual school infrastructure more accurately. Another improvement to the school infrastructure capability stock would be to break up the stock into many different variables. Instead of it being one variable it would be broken up into all of the parts. This would allow separate values for each of variables, which could be helpful in judging the sensitivity of the system to certain variables. The value for school infrastructure was one of the most difficult values to determine and it is not clear if breaking it up into different variables will make it easier or harder to come up with appropriate values.

One small change to the model that could change the dynamics of the model would be to have three different stocks for high school students instead of just having two. At the moment the model only has low and high risk students. This binary view of high school may be too simplified. To make the model more complex students should be divided into low risk, high risk, and medium risk students. It is more realistic to say that many students would fall into this medium risk category. This would add a large amount of complexity with these students moving between high and low risk and would eventually become the key as to whether a school succeeds or fails.

A final large change to the model would be to strongly link the success or failure of a school to the economics of the area. This would create very large and complex model, but one that would be very helpful and interesting. This model would include housing and land values, crime rates, businesses, industrial complexes, population density, and many other factors that could tie into the educational success of an area which would in turn impact these factors. For example, the community quality of an area would impact the land and housing values, which would cause low risk families to move out bringing in high risk families which would cause crime rates to rise and more high risk students to enter the school. The dynamics of this model and the results that it would provide would be extremely interesting.

## Chapter 7: Conclusion

No Child Left Behind was enacted to help create an educational environment that will be conducive to helping at risk students. For areas such as Sacramento City and Palm Springs, this help was necessary. Both of these districts were far below average in student performance and needed a way to bring their grades up. Both districts have a below average economy and a high level of minorities. But while Sacramento City improved its performance on standardized tests, Palm Springs continued to a show a decline. No Child Left Behind not only was unsuccessful in stopping this decline, it also aided in increasing the rate at which the district failed these tests. While Palm Springs spent money on remedial programs instead of maintaining an already weak infrastructure, Sacramento City was able to spend money on building up their infrastructure. Sacramento City's performance slowly increased over the years until No Child Left Behind kicked in. At this point Sacramento City's performance increase stalled because of a need to change focus to remedial programs. At its current state, No Child Left Behind does not seem to be able to create and sustain a high level of performance for those districts that are at risk.

With a combination of changes to the policy, No Child Left Behind can be successful in many more districts than it currently has been. A less rigid adequate yearly progress schedule, less focus on remedial programs, more focus on school infrastructure, and more funding would all aid in improving the success of No Child Left Behind. Although the model that was created does not and can not answer all the problems that are inherent within this system, it does go a long way in providing an overview of the educational setting and how No Child Left Behind impacts low and high risk students.

This paper illustrates the benefits of performing a system dynamics analysis on a complex problem. It allows you to see how the system behaves under slight changes to certain values. It allows us to examine every element of the system and then how each of these elements interacts with each other in order to create system wide behavior. Properly using system dynamics techniques will allow policy makers, researchers, and school administrators to improve educational policy and create a better educational environment for both low and high risk students.

## Appendix:  Stella Model Equations

### Achievement

Consecutive_Shortfall_Years(t) = Consecutive_Shortfall_Years(t - dt) + (Increment_shortfall_yrs - Clean_the_slate) * dt
INIT Consecutive_Shortfall_Years = 0
INFLOWS:
Increment_shortfall_yrs = if(NCLB_Shutdown = 1) then (if (Compliance_Shortfall = -1) then 1 else 0) else 0
OUTFLOWS:
Clean_the_slate = if(Massive_Overhaul_Choice = 0) then (if (NCLB_Shutdown=1) then (if (Consecutive_Shortfall_Years < 6) then (if (history(Compliance_Shortfall, Time - 1) = 1 and Compliance_Shortfall = 1) then Consecutive_Shortfall_Years else 0) else 0) else 0) else 30
Assumed_pass_rate_of_high_achievers = Impact_of_SI_on_Performance_of_high_achievers
Assumed_pass_rate__low_achievers = Impact_of_SI_on_Performance_of_low_achievers
Calculated_Required_Pass_Rate = if (round(history(Student_Performance, time - 1) + 2) > 100 or round(history(Student_Performance, time - 1) + 1) > 100) then 100 else history(Student_Performance, time - 1) + 2
Compliance_Shortfall = if(NCLB_Scenario__Choice = 1) then (If (Student_Performance < Current_Required_Pass_Rate) then -1 else 1)
else If (NCLB_Scenario__Choice = 2) then (if (Student_Performance < Modified_Required_Pass_Rate) then -1 else 1)
else if (NCLB_Scenario__Choice = 3) then (if (Student_Performance < Calculated_Required_Pass_Rate) then -1 else 1) else 1
Massive_Overhaul_Choice = 0
NCLB_Scenario__Choice = 1
Student_Performance = round(((Assumed_pass_rate_of_high_achievers*HS_Age_Low_Risk+(Assumed_pass_rate__low_achievers*HS_Age_High_Risk))/(HS_Age_Low_Risk+HS_Age_High_Risk))*100)
Current_Required_Pass_Rate = GRAPH(TIME)
(0.00, 10.0), (1.00, 10.0), (2.00, 10.0), (3.00, 21.0), (4.00, 21.0), (5.00, 21.0), (6.00, 33.0), (7.00, 44.0), (8.00, 55.0), (9.00, 66.0), (10.0, 78.0), (11.0, 89.0), (12.0, 100), (13.0, 100), (14.0, 100), (15.0, 100), (16.0, 100), (17.0, 100), (18.0, 100), (19.0, 100), (20.0, 100)
Modified_Required_Pass_Rate = GRAPH(TIME)
(0.00, 10.0), (1.00, 10.0), (2.00, 10.0), (3.00, 21.0), (4.00, 21.0), (5.00, 21.0), (6.00, 25.0), (7.00, 31.0), (8.00, 35.0), (9.00, 41.0), (10.0, 44.0), (11.0, 48.0), (12.0, 52.0), (13.0, 58.0), (14.0, 64.0), (15.0, 70.0), (16.0, 76.0), (17.0, 82.0), (18.0, 88.0), (19.0, 94.0), (20.0, 100)

### Demographics and School Progression

Economic_Contributors(t) = Economic_Contributors(t - dt) + (Low_Risk_Graduates + High_Risk_Graduates - Movement_of_Economic_Contributors - Post_School_Economic_Contributor_Deaths) * dt
INIT Economic_Contributors = Initial_Population*Initial_Econonic_Health*.725
INFLOWS:
Low_Risk_Graduates = Low_Risk_Graduation_Rate*HS_Age_Low_Risk
High_Risk_Graduates = High_Risk_Graduation_Rate*HS_Age_High_Risk
OUTFLOWS:
Movement_of_Economic_Contributors = Economic_Contributors*Impact_of_CQI_on_Economic_Contributors*.725
Post_School_Economic_Contributor_Deaths = Economic_Contributors*(Death_Rate+.008)
Economic_Detractors(t) = Economic_Detractors(t - dt) + (Movement_of_Economic_Detractors + Low_Risk_Drop_Outs + High_Risk_Drop_Outs - Post_School_Economic_Detractor_Deaths) * dt
INIT Economic_Detractors = Initial_Population*(1-Initial_Econonic_Health)*.725
INFLOWS:
Movement_of_Economic_Detractors = Economic_Detractors*Impact_of_CQI_on_Economic_Detractors*.725
Low_Risk_Drop_Outs = Low_Risk_Drop_Out_Rate*HS_Age_Low_Risk
High_Risk_Drop_Outs = High_Risk_Drop_Out_Rate*HS_Age_High_Risk
OUTFLOWS:
Post_School_Economic_Detractor_Deaths = Economic_Detractors*(Death_Rate+.008)
Fleeing_Detractors(t) = Fleeing_Detractors(t - dt) + (-Movement_of_Economic_Detractors) * dt
INIT Fleeing_Detractors = 0
OUTFLOWS:
Movement_of_Economic_Detractors = Economic_Detractors*Impact_of_CQI_on_Economic_Detractors*.725
Fleeing_Economic_Contributors(t) = Fleeing_Economic_Contributors(t - dt) + (Movement_of_Economic_Contributors) * dt
INIT Fleeing_Economic_Contributors = 0
INFLOWS:
Movement_of_Economic_Contributors = Economic_Contributors*Impact_of_CQI_on_Economic_Contributors*.725
Fleeing_High_Risk(t) = Fleeing_High_Risk(t - dt) + (- HS_Age_High_Risk_Movement) * dt
INIT Fleeing_High_Risk = 0
OUTFLOWS:
HS_Age_High_Risk_Movement = HS_Age_High_Risk*Impact_of_CQI_on_Economic_Detractors*.06*School_Chioce_Multiplier
Fleeing_Low_Risk(t) = Fleeing_Low_Risk(t - dt) + (HS_Age_Low_Risk_Movement) * dt
INIT Fleeing_Low_Risk = 0
INFLOWS:

HS_Age_Low_Risk_Movement =
HS_Age_Low_Risk*Impact_of_CQI_on_Economic_Contributors*.06 *
School_Chioce_Multiplier
HS_Age_High_Risk(t) = HS_Age_High_Risk(t - dt) + (Pre_HS_High_Risk_to_HS +
Academic_Decrease + HS_Age_High_Risk_Movement - Academic_Improvement -
High_Risk_Graduates - High_Risk_Drop_Outs - HS_Age_High_Risk_Deaths) * dt
INIT HS_Age_High_Risk = Initial_Population*(1-Initial_School_Performance)*.06
INFLOWS:
Pre_HS_High_Risk_to_HS = 1/Years_til_High_School* Pre_HS_Age_High_Risk
Academic_Decrease = HS_Age_Low_Risk*Impact_of_Capability_on_Low_Risk
HS_Age_High_Risk_Movement =
HS_Age_High_Risk*Impact_of_CQI_on_Economic_Detractors*.06*School_Chioce_Multiplier
OUTFLOWS:
Academic_Improvement = HS_Age_High_Risk *
(Remedial_Spending_Impact*Remedial_Spending__Quality) +
(Impact_of_Capability_on_High_Risk * HS_Age_High_Risk)
High_Risk_Graduates = High_Risk_Graduation_Rate*HS_Age_High_Risk
High_Risk_Drop_Outs = High_Risk_Drop_Out_Rate*HS_Age_High_Risk
HS_Age_High_Risk_Deaths = HS_Age_High_Risk*(Death_Rate - .004)
HS_Age_Low_Risk(t) = HS_Age_Low_Risk(t - dt) + (Pre_HS_Low_Risk_to_HS +
Academic_Improvement - Academic_Decrease - Low_Risk_Graduates -
Low_Risk_Drop_Outs - HS_Age_Low_Risk_Deaths - HS_Age_Low_Risk_Movement)
* dt
INIT HS_Age_Low_Risk = Initial_Population*Initial_School_Performance*.06
INFLOWS:
Pre_HS_Low_Risk_to_HS = 1/Years_til_High_School * Pre_HS_Age_EC
Academic_Improvement = HS_Age_High_Risk *
(Remedial_Spending_Impact*Remedial_Spending__Quality) +
(Impact_of_Capability_on_High_Risk * HS_Age_High_Risk)
OUTFLOWS:
Academic_Decrease = HS_Age_Low_Risk*Impact_of_Capability_on_Low_Risk
Low_Risk_Graduates = Low_Risk_Graduation_Rate*HS_Age_Low_Risk
Low_Risk_Drop_Outs = Low_Risk_Drop_Out_Rate*HS_Age_Low_Risk
HS_Age_Low_Risk_Deaths = HS_Age_Low_Risk*(Death_Rate - .004)
HS_Age_Low_Risk_Movement =
HS_Age_Low_Risk*Impact_of_CQI_on_Economic_Contributors*.06 *
School_Chioce_Multiplier
Pre_HS_Age_EC(t) = Pre_HS_Age_EC(t - dt) + (Low_Risk_Births -
Pre_HS_Low_Risk_to_HS - Pre_HS_Age__Low_Risk_Deaths -
Movement_of_Pre__HS_Age_Low_Risk) * dt
INIT Pre_HS_Age_EC = Initial_Population*Initial_Econonic_Health*.215
INFLOWS:
Low_Risk_Births = Birth_Rate*(Economic_Contributors+HS_Age_Low_Risk)
OUTFLOWS:
Pre_HS_Low_Risk_to_HS = 1/Years_til_High_School * Pre_HS_Age_EC

Pre_HS_Age__Low_Risk_Deaths = Pre_HS_Age_EC*(Death_Rate - .004)
Movement_of_Pre__HS_Age_Low_Risk =
Pre_HS_Age_EC*Impact_of_CQI_on_Economic_Contributors*.215
Pre_HS_Age_High_Risk(t) = Pre_HS_Age_High_Risk(t - dt) + (High_Risk_Births +
Movement_of_Pre__HS_Age_High_Risk - Pre_HS_High_Risk_to_HS -
Pre_HS_Age__High_Risk_Deaths) * dt
INIT Pre_HS_Age_High_Risk = Initial_Population*(1-Initial_Econonic_Health)*.215
INFLOWS:
High_Risk_Births = Birth_Rate*(HS_Age_High_Risk+Economic_Detractors)
Movement_of_Pre__HS_Age_High_Risk =
Pre_HS_Age_High_Risk*Impact_of_CQI_on_Economic_Detractors*.215
OUTFLOWS:
Pre_HS_High_Risk_to_HS = 1/Years_til_High_School* Pre_HS_Age_High_Risk
Pre_HS_Age__High_Risk_Deaths = Pre_HS_Age_High_Risk*(Death_Rate - .004)
Birth_Rate = .022
Community_Quality_Index = (Economic_Health_Percentage * .5 +
(Student_Performance/200))
Death_Rate = .008
Economic_Health_Percentage =
Economic_Contributors/(Economic_Contributors+Economic_Detractors)
High_Risk_Drop_Out_Rate = Impact_of_SI_on_Drop_Out_Rate
High_Risk_Graduation_Rate = .25 - High_Risk_Drop_Out_Rate
Initial_School_Performance = .5
Low_Risk_Drop_Out_Rate = 0
Low_Risk_Graduation_Rate = .25
Remedial_Spending__Quality = 1
School_Chioce_Multiplier = 1
Total_Number___of_Students = HS_Age_High_Risk+HS_Age_Low_Risk
Years_til_High_School = 13
Impact_of_CQI_on_Economic_Contributors = GRAPH(Community_Quality_Index)
(0.00, 0.1), (0.1, 0.08), (0.2, 0.06), (0.3, 0.04), (0.4, 0.02), (0.5, 0.00), (0.6, -0.02), (0.7, -0.04), (0.8, -0.06), (0.9, -0.08), (1, -0.1)
Impact_of_CQI_on_Economic_Detractors = GRAPH(Community_Quality_Index)
(0.00, -0.1), (0.1, -0.08), (0.2, -0.06), (0.3, -0.04), (0.4, -0.02), (0.5, 0.00), (0.6, 0.02), (0.7, 0.04), (0.8, 0.06), (0.9, 0.08), (1, 0.1)

**Funding**

Local_Taxes(t) = Local_Taxes(t - dt) + (Money_In - Tax_Funds__for_Education -
Non_Educational_Funds) * dt
INIT Local_Taxes =
(Economic_Contributors*Contributor_Tax_Rate+(Detractor__Tax_Rate*Economic_Detractors))*Percent_Increase_in_Local_Taxes
INFLOWS:

Money_In =
Economic_Contributors*Contributor_Tax_Rate+(Economic_Detractors*Detractor__Tax_Rate)
OUTFLOWS:
Tax_Funds__for_Education = Local_Taxes*Education_Funding_Rate
Non_Educational_Funds = (1-Education_Funding_Rate) * Local_Taxes
Long_Term_Spending(t) = Long_Term_Spending(t - dt) + (NCLB_Long_Term_Spending_Rate + Tax_Funds__for_Education + Long_Term_State_Funding - Yearly_Allowance - Yearly_Decay) * dt
INIT Long_Term_Spending = .8 * NCLB_Funding + (Local_Taxes * Education_Funding_Rate*Percent_Increase_in_Local_Taxes) + (State_Funding * .8) + (.02 * NCLB_Funding)
INFLOWS:
NCLB_Long_Term_Spending_Rate = (NCLB_Funding * (1-Spending_Schedule))
Tax_Funds__for_Education = Local_Taxes*Education_Funding_Rate
Long_Term_State_Funding = State_Long_Term_Spending_Rate*State_Funding
OUTFLOWS:
Yearly_Allowance = Long_Term_Spending*Long_Term_Spending_Rate
Yearly_Decay = Long_Term_Spending*(1-Long_Term_Spending_Rate)
NCLB_Funding(t) = NCLB_Funding(t - dt) + (Federal_Funding_Rate_for_NCLB + Reward_Funding - NCLB_Remedial__Spending_Rate - NCLB_Long_Term_Spending_Rate) * dt
INIT NCLB_Funding = (HS_Age_High_Risk*Funding_per_At__Risk_Pupil) + (HS_Age_Low_Risk*Funding_Per_Low_Risk_Pupil)
INFLOWS:
Federal_Funding_Rate_for_NCLB = ((HS_Age_High_Risk*Funding_per_At__Risk_Pupil) + (HS_Age_Low_Risk*Funding_Per_Low_Risk_Pupil))*NCLB_Shutdown
Reward_Funding = if(Time > 2) then (If (history(Consecutive_Shortfall_Years, Time - 1) = 0 and history(Consecutive_Shortfall_Years, Time - 2) = 0 and Consecutive_Shortfall_Years = 0) then .02 * NCLB_Funding else 0) else 0
OUTFLOWS:
NCLB_Remedial__Spending_Rate = NCLB_Funding*Spending_Schedule
NCLB_Long_Term_Spending_Rate = (NCLB_Funding * (1-Spending_Schedule))
Remedial_Funding(t) = Remedial_Funding(t - dt) + (NCLB_Remedial__Spending_Rate + Remedial_State__Funding - Remedial_Spending) * dt
INIT Remedial_Funding = ((1-State_Long_Term_Spending_Rate)*State_Funding + (NCLB_Funding*Spending_Schedule))*Percent_Increase__in_Remedial_Funding
INFLOWS:
NCLB_Remedial__Spending_Rate = NCLB_Funding*Spending_Schedule
Remedial_State__Funding = (1-State_Long_Term_Spending_Rate)*State_Funding
OUTFLOWS:
Remedial_Spending = Remedial_Funding*Remedial_Deployment_Rate
State_Funding(t) = State_Funding(t - dt) + (State_Funding__Rate - Long_Term_State_Funding - Remedial_State__Funding) * dt
INIT State_Funding = Total_Number___of_Students*State_Funding__per_Student

INFLOWS:
State_Funding__Rate =
State_Funding__per_Student*Total_Number___of_Students*State_Funding_Rate
OUTFLOWS:
Long_Term_State_Funding = State_Long_Term_Spending_Rate*State_Funding
Remedial_State__Funding = (1-State_Long_Term_Spending_Rate)*State_Funding
Contributor_Tax_Rate = 4500
Current_Year = 1
Detractor__Tax_Rate = 2000
Education_Funding_Rate = .1
Funding_per_At__Risk_Pupil = 1300
Funding_Per_Low_Risk_Pupil = if (Funding_per_At__Risk_Pupil > 1200) then 0 else (Funding_per_At__Risk_Pupil-1200)
Long_Term_Funding__per_Student = Yearly_Allowance/Total_Number___of_Students
Long_Term_Spending_Rate = .70
NCLB_Shutdown = 1
Percent_Increase_in_Local_Taxes = 1
Percent_Increase__in_Remedial_Funding = 1
Remedial_Deployment_Rate = 1
Remedial_Spending_per_Student = Remedial_Spending/Total_Number___of_Students
Remedial_to_Long__Term_Ratio = (Remedial_Funding)/Long_Term_Spending
Spending_Schedule = if(Consecutive_Shortfall_Years = 2) then .5 else if (Consecutive_Shortfall_Years = 3) then .6 else if (Consecutive_Shortfall_Years = 4) then .7 else if (Consecutive_Shortfall_Years >= 5) then .8 else .3
State_Funding_Rate = 1
State_Funding__per_Student = 8000
State_Long_Term_Spending_Rate = .8
Total_Funding_per_Student =
(Long_Term_Funding__per_Student+Remedial_Spending_per_Student)*Current_Year
Long_Term_Funding_Impact_on_Capabiilty =
GRAPH((Long_Term_Funding__per_Student))
(6000, 1.92), (6300, 4.30), (6600, 6.50), (6900, 8.20), (7200, 9.30), (7500, 10.5), (7800, 12.0)
Remedial_Spending_Impact = GRAPH(Remedial_Spending_per_Student)
(1000, 0.002), (1200, 0.011), (1400, 0.0255), (1600, 0.0315), (1800, 0.0345), (2000, 0.0395), (2200, 0.044), (2400, 0.049), (2600, 0.0525), (2800, 0.057), (3000, 0.0765)

**School Infrastructure**

School_Infrastructure_Performance_Capability(t) =
School_Infrastructure_Performance_Capability(t - dt) + (Capability_Increase - Capability__erosion) * dt
INIT School_Infrastructure_Performance_Capability = 50
INFLOWS:
Capability_Increase = if(Massive_Overhaul_Choice = 2) then 50 else if (Massive_Overhaul_Choice = 5) then 25 else (if(NCLB_Shutdown = 1) then

(if(School_Infrastructure_Performance_Capability <= 100) then
Long_Term_Funding_Impact_on_Capabiilty else 0) else 0)
OUTFLOWS:
Capability__erosion = if(NCLB_Shutdown = 1) then Erosion_Factor else 0
Erosion_Factor = 9.2
Impact_of_Capability_on_High_Risk =
GRAPH(School_Infrastructure_Performance_Capability)
(0.00, 0.00), (10.0, 0.00), (20.0, 0.00), (30.0, 0.025), (40.0, 0.03), (50.0, 0.035), (60.0,
0.045), (70.0, 0.075), (80.0, 0.08), (90.0, 0.08), (100, 0.16)
Impact_of_Capability_on_Low_Risk =
GRAPH(School_Infrastructure_Performance_Capability)
(0.00, 0.22), (10.0, 0.2), (20.0, 0.18), (30.0, 0.15), (40.0, 0.11), (50.0, 0.06), (60.0, 0.03),
(70.0, 0.02), (80.0, 0.00), (90.0, 0.00), (100, 0.00)
Impact_of_SI_on_Drop_Out_Rate =
GRAPH(School_Infrastructure_Performance_Capability)
(0.00, 0.2), (10.0, 0.17), (20.0, 0.14), (30.0, 0.11), (40.0, 0.07), (50.0, 0.05), (60.0, 0.05),
(70.0, 0.03), (80.0, 0.02), (90.0, 0.01), (100, 0.00)
Impact_of_SI_on_Performance_of_high_achievers =
GRAPH(School_Infrastructure_Performance_Capability)
(0.00, 0.4), (10.0, 0.55), (20.0, 0.7), (30.0, 0.85), (40.0, 0.95), (50.0, 1.00), (60.0, 1.00),
(70.0, 1.00), (80.0, 1.00), (90.0, 1.00), (100, 1.00)
Impact_of_SI_on_Performance_of_low_achievers =
GRAPH(School_Infrastructure_Performance_Capability)
(0.00, 0.001), (10.0, 0.008), (20.0, 0.01), (30.0, 0.015), (40.0, 0.02), (50.0, 0.035), (60.0,
0.04), (70.0, 0.04), (80.0, 0.07), (90.0, 0.1), (100, 0.12)

**Statistics**

Federal_Funding_Ratio =
Federal_Funding_Rate_for_NCLB/(Federal_Funding_Rate_for_NCLB+State_Funding_
_Rate+Tax_Funds__for_Education)
Graduate_to_Drop_Out_Ratio = (High_Risk_Graduates+Low_Risk_Graduates)/
(if((High_Risk_Drop_Outs + Low_Risk_Drop_Outs) < 1) then 1 else
(High_Risk_Drop_Outs+Low_Risk_Drop_Outs))
Initial_Econonic_Health = .5
Initial_Population = 35000
Local_Funding_Ratio =
Tax_Funds__for_Education/(Federal_Funding_Rate_for_NCLB+State_Funding__Rate+
Tax_Funds__for_Education)
Overall_Population =
HS_Age_Low_Risk+HS_Age_High_Risk+Economic_Contributors+Economic_Detracto
rs+Pre_HS_Age_EC+Pre_HS_Age_High_Risk
State_Funding_Ratio =
State_Funding__Rate/(Federal_Funding_Rate_for_NCLB+State_Funding__Rate+Tax_F
unds__for_Education)

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