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DAT495 ASU
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The Learning Crisis in Arizona

Primary Company details:

Founded - 2014
Founders - Sophie Allen-Etchart
Headquarters - Phoenix, AZ
Categories - Non-profit, Education

Address:

4730 West Campbell Ave,
Phoenix, AZ 85031
Website: www.ReadBetterBeBetter.org

Business Description:

Read Better Be Better helps with children's literacy by hosting an after school program. Coaches teach after school for an hour or so. The company is a non-profit and it's all across Phoenix schools currently. The organization mostly looks to improve students who are struggling reading. Students are encouraged to participate by the program coaches. Elementary students pair up with middle school students called "Leaders" and work together to read different books.

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Executive Summary

Investigation

Arizona has been known to be one of the worst states in education. Our funding is low, and our test scores are much worse than the rest of the United States. Finding the biggest factors in our low test scores is necessary to enact a plan for future learning. Arizona is unique in that it has a large Hispanic population. We are not like other states because English is a second language for many students.

Objective

The objective of this research is to identify the factors that affect reading test scores in Arizona Students over the last five years. The effect of Covid-19 on our education cannot be overlooked as well. These factors will help determine the impact that Read Better Be Better has made upon students. Specifically, I wish to examine the improvement among the Readers rather than the Leaders that help younger students. The program has yet to see truly the extent of improvement upon reading comprehension.

Solution

The study intends to improve the current data collection done by Read Better Be Better. In addition, I intend to generate a better perspective for parents wishing to enroll their student in the program. The research also shows that improvement is much more likely for students who have poor scores to begin with.

Research Questions

**RQ1: Do reading scores correlate with the average income of the county?
Demographics? District Spending? Free or Reduced Lunch?**

Being able to predict test scores based on how much income allows my organization to allocate more resources to the students who need it. How correlated is the funding of schools to the income of the area? Are these schools' reading scores being affected even worse because teachers are being paid less? This would also help explain these schools refusing the Read Better Be Better program because of funding.

RQ2: What predicts the most improvement in reading scores based on demographics and survey answers? How well does Read Better Be Better improve scores?

Many schools report beginning and end of the year test scores. Would be interesting to see if wealthy areas also show more improvement over time.

RQ3: How has education been affected by covid?

The way we have taught students during covid was massively different. Schools had to go entirely online for 2020 up until the Fall of 2021. Every student was affected differently but this is particularly interesting for elementary schoolers who don't have access to technology.

**H1: Lower income areas will suffer from inexperienced teachers and worse scores.
Demographics and income will likely have tons of interaction.**

Less resources have generally made it more difficult for students to learn. However, the environment these kids are in likely play a heavy role on their scores. Having constant new teachers likely would contribute to lower scores. Teachers who are paid less are also less qualified which I believe will also worsen learning. Demographics in the United States has been extremely correlated

H2: Variables such as a higher pre test score and higher income will result in more improvement. RBBB Students should show improvement but not as much compared to higher performing students.

Students who have lower test scores are likely to continue being discouraged from learning. A lack of motivation to learn probably starts with a lack of confidence in academic ability. RBBB Students are mostly in low performing schools and will therefore have more improvement compared to the students at their own school.

H3: Covid has likely worsened test scores and hindered the improvement of students.

Analyzing the combination of the first two research requisitions while comparing the years prior, during, and after will give a better picture to how students have been performing. Due to the unpreparedness of teachers, the scores should be lower.

Literature Review

Background

Education has been a topic of research for many years. Our current education system in the United States is not exactly perfect by any means. Education hasn't been a focus for the government for a long time and as a result, teachers and schools are underpaid. It's quite obvious how important the education of our children is. Education correlates very heavily with success however you define it. Wealth and happiness are determined largely by education and environment.

Related information closer to research

Plenty of research has already been done looking into the relation between economic status and education. Studies have found that test scores especially such as the SAT are very highly correlated with income. Income not only determines a resource a student is able to use, but it also identifies the environment of students. A study was conducted in Sweden that took a dive into the correlation with students in a similar environment. Once again it looked at both GPA and test scores with the variables Parental Income, Parental Education, and the interaction term between these two for Males and Females. The study was looking for the correlation with neighbors and classmates. Income had a much stronger correlation for both GPA and test scores than education. The biggest takeaway from this experiment was that test scores among classmates had a strong correlation, more so than being neighbors. Being siblings resulted in even more correlation. "We know relatively little about why siblings are so similar in terms of future outcomes" (Lindale). Environment is the best explanation for this. Being in the same school didn't have that much correlation but the scores of people in direct contact of a student proved to be the most important factor in determining a student's success. The income provides an additional boost, but being around other students who are succeeding goes miles.

My research focuses on the test scores of students, but is that the best predictor of future success? A study at the University of Chicago found otherwise. Although SAT scores still provide worthy evaluation, the GPA of students better predicted college success. As a result, UChicago became the first highly selective college to make standardized tests optional in the application process” (“Test scores don’t stack up to GPAs in predicting college success”). The issue is that my research is focused on elementary students. There is no better way to judge success besides the test scores provided. Schools do not record a GPA for elementary students. Therefore the best predictor of success is test scores for these students.

This begs the question: do the lower performing students see less improvement over time? If the environment of students determines success, wouldn’t students who fall behind continue to do so? The answer is yes, there is a snowball effect with low performing students missing class, increased teen pregnancy, and dropout rates. Low test scores interfere with students' encouragement to learn.

My final question on the effect of covid on test scores has recurring findings too. There are so many more variables that the pandemic presented, but research has found there to be an unprecedented decline in both reading and math scores. High performing students and low performing students both had a sharp decline. The complication of online learning resulted in less interaction between students and teachers. Many parents lost their jobs and a spike in mental health issues resulted.

Directly Relevant Info

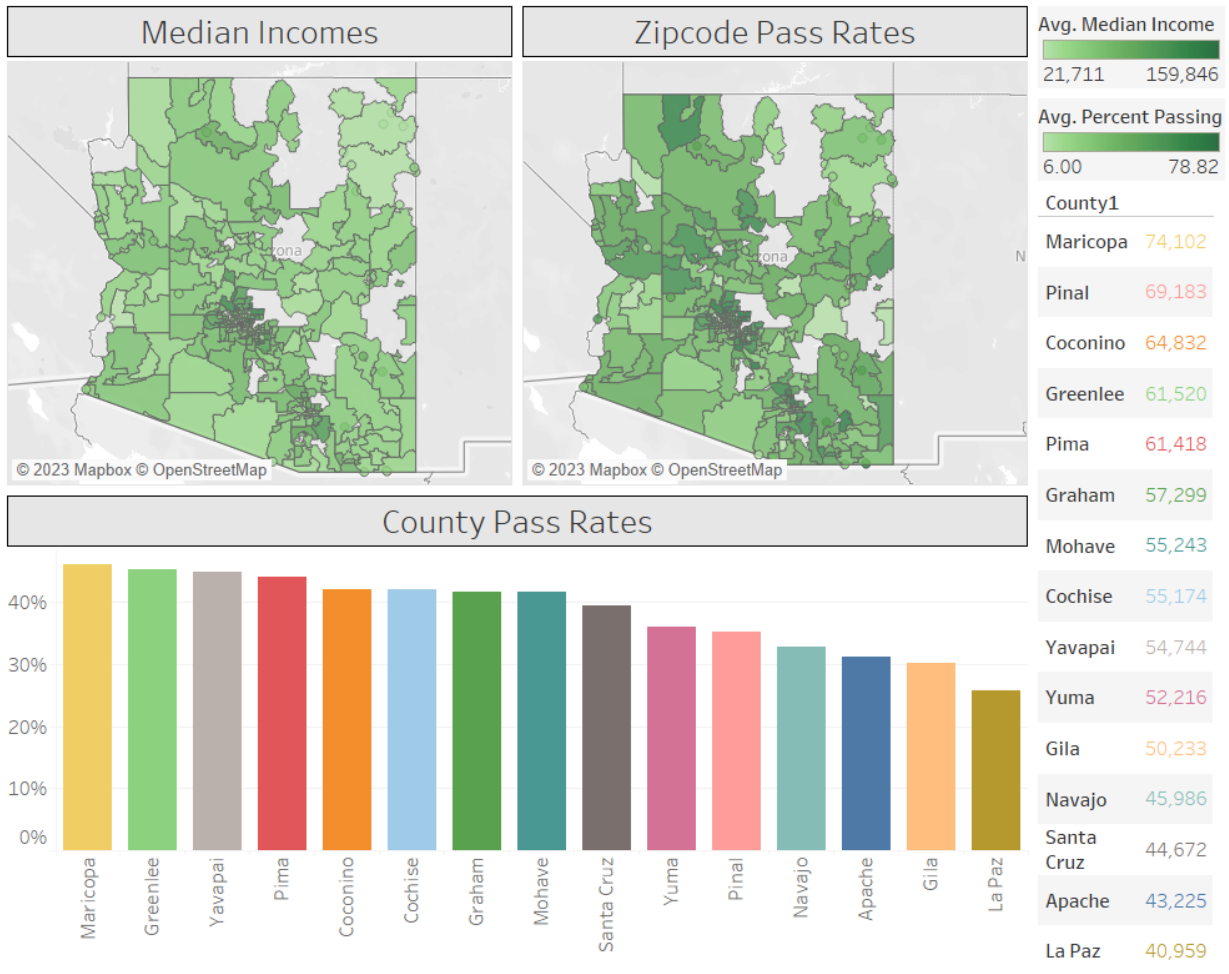
Arizona is an interesting case for education. We rank very poorly in every segment of education. Our teacher retention rate is the worst in the country. We ranked 49th in teacher salary as well. Public schools contain “95% of Arizona families” (Sosa). Sosa conducted a study to determine student success and found that experienced and well-trained teachers mattered more than any other factor. Yet fewer teachers are looking to enter the field and Covid made this problem even worse.

Studies have shown that math scores especially are influenced by income whereas reading is less of an effect. At Read Better Be Better the focus is solely on literacy of students. The correlation between the reading scores and income is still high though. This is likely due to a difference in accessible materials.

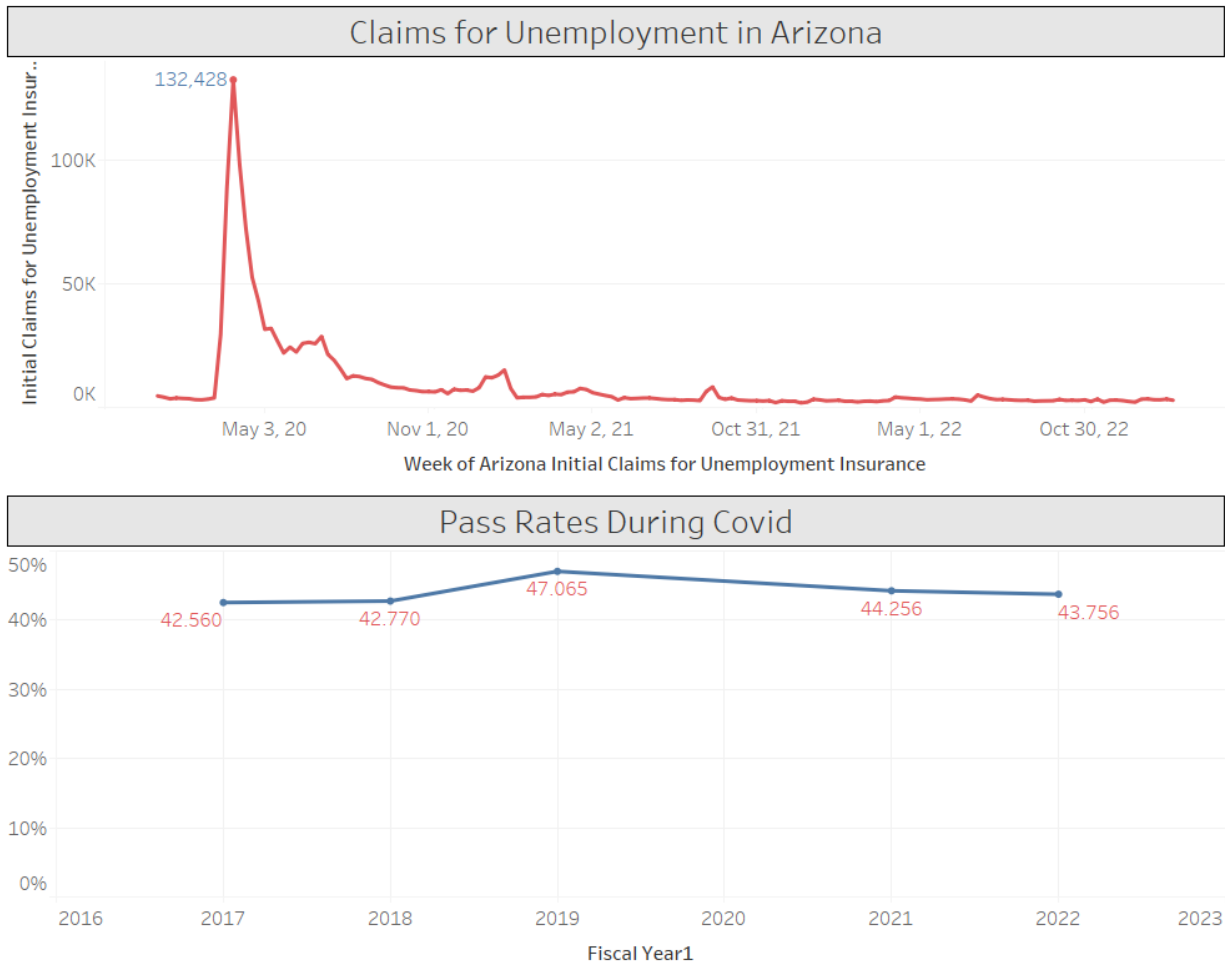
Unfortunately from a data scientists perspective, lawmakers banned the use of standardized tests to rank schools. Luckily, Governor Ducey still required testing to “identify the extent of learning loss” (AZPBS). Despite Arizona having much worse funding, the effect of covid on scores was the same as the rest of the country. “Results released by the department Friday showed that 38% of students got “satisfactory” grades on the language test and 31% passed the math test in 2021, compared to 42% for both tests in 2019, the last year for which test results are available.” (AZPBS).

Data Exploration

When I first visualized the data I was looking for more background information on the questions I was asking. I first decided to examine the bigger picture of Arizona as a whole. I tried to see if there was any pattern in income based upon county scores. Deeper analysis is required for the effect of covid on income. I then looked to see how students were performing between the different grade levels being tested. Read Better Be Better contains mostly 3rd graders, but middle schoolers act as leaders for them and seeing their improvement is welcome as well. Next was to look at the different demographics performance of RBBB students. Finally I looked at the actual effect of the program on scores.



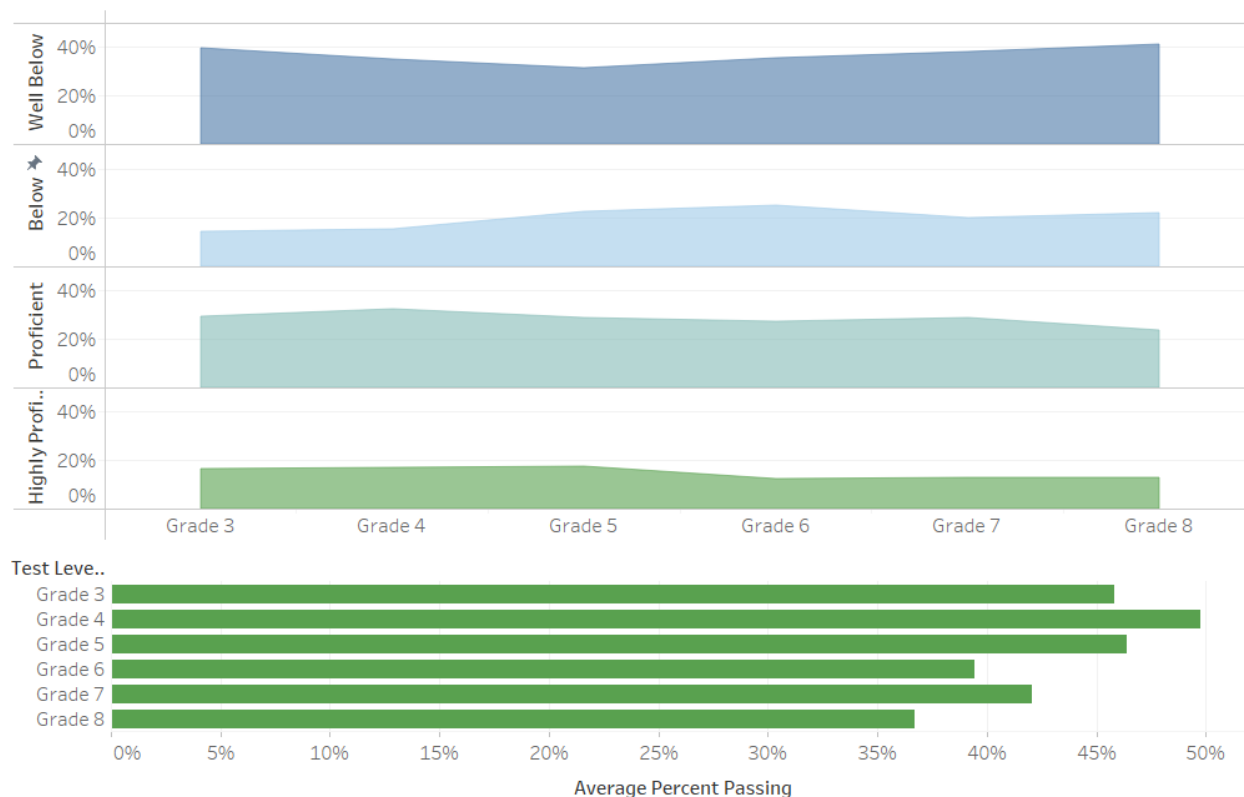
There seems to be a correlation between income and the amount of elementary and middle school students passing literacy tests. The counties with the highest median income (Maricopa, Coconino, Pima, and Yavapai) have the highest passing percent as well. However, the counties with the highest passing percent also tend to have the highest populations as well. The counties that performed the best contain the largest cities in Arizona: Phoenix, Tucson, and Flagstaff.



The amount of money being made lower and middle income households in Arizona actually increased in Arizona. The unemployment rates however spiked like the rest of the country. The dividends are included in income, but there is more to the equation. While wages increased, it has been met with much more spending inflation. These classes still suffered in the pandemic while the upper class stayed steady. The passing rates took a dip during covid as well. Also, weirdly enough the passing rates increased drastically the following year.

2,464,307 Student Tests	1,598 Schools Tested	44.04% Pass Rate
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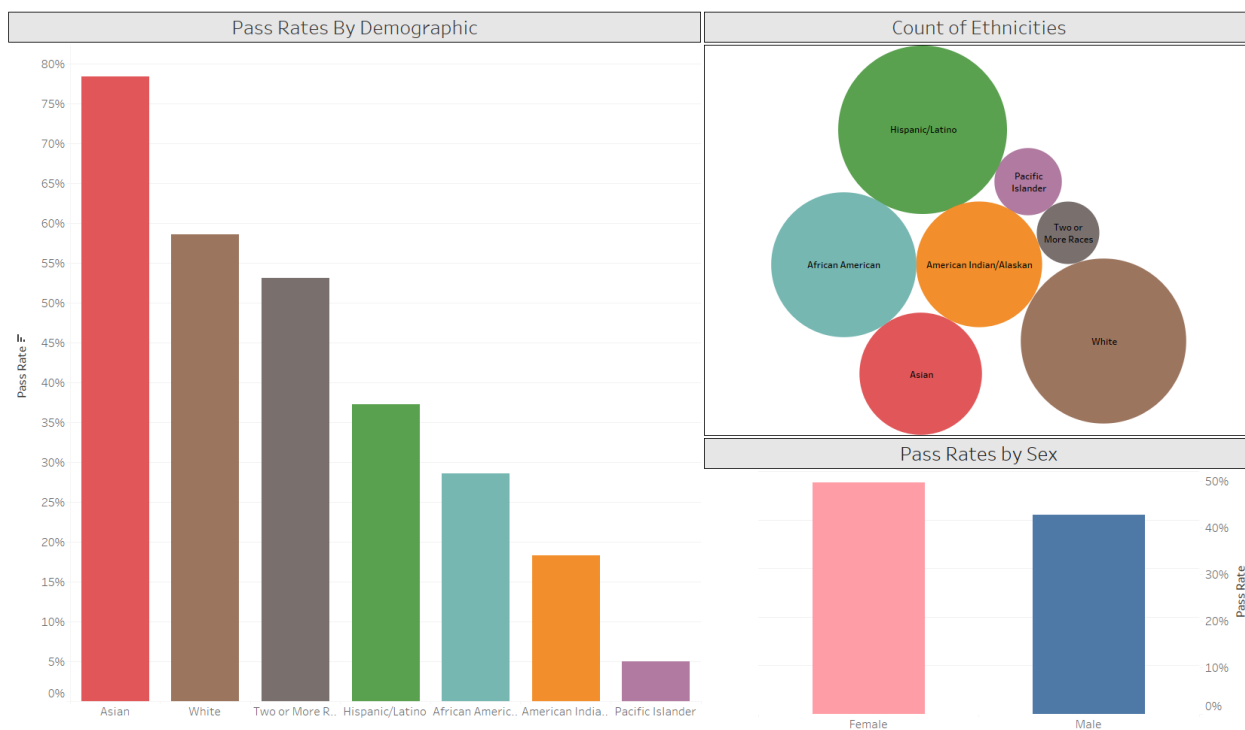
Student Proficient Over Time



Students were tested at the end of the year throughout 2017-2022.

It seems that the variability in elementary students' scores is much lower than middle school.

There are much less highly proficient middle schoolers. This points to a general loss in enthusiasm for learning when students reach middle school. There is the greatest dip as students transition from elementary to middle school. Shockingly, the majority of students are within the well below benchmark. There seems to be a lot of variability with students because not many are in the below benchmark, especially in 3rd grade.

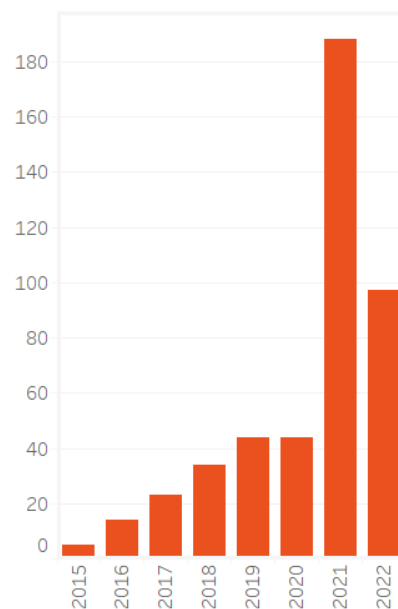
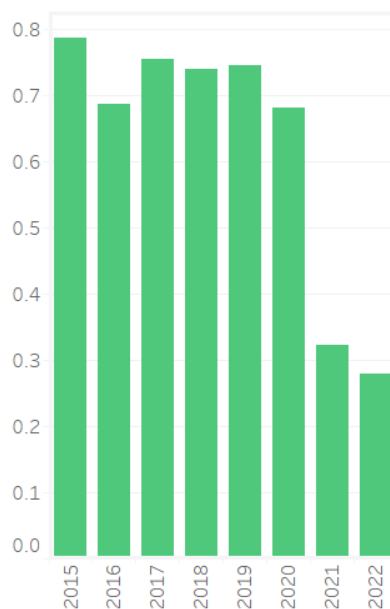
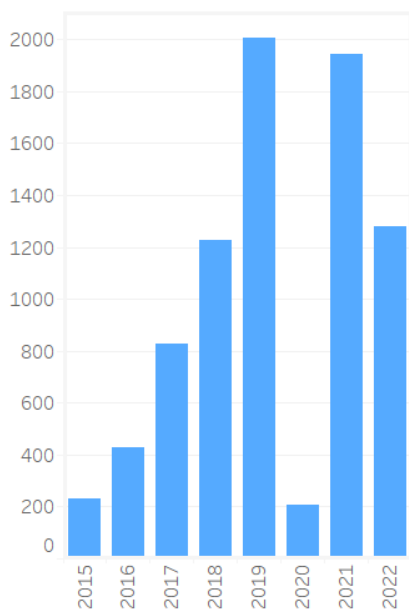


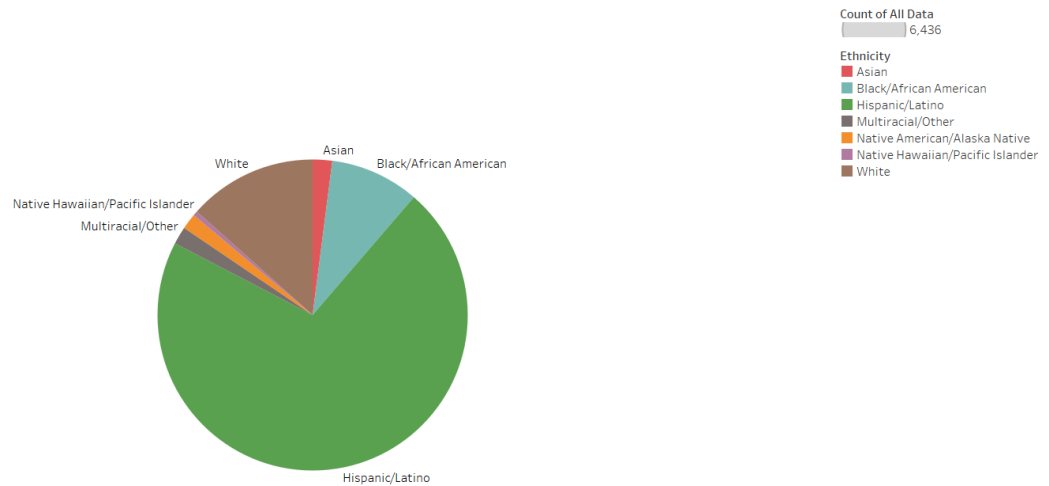
Race seems to have an incredibly high effect on passing rates. Asian students in particular have a much higher passing rate than any other race. White students follow and every other race is much lower. Both Native Americans and Pacific Islanders perform significantly lower than other races. Female students seem to outperform males as well. RBBB has a very large Hispanic population but they are trying to target students who perform worse.

8,151
RBBB Students

58.96%
Attendance Rate

227
Schools

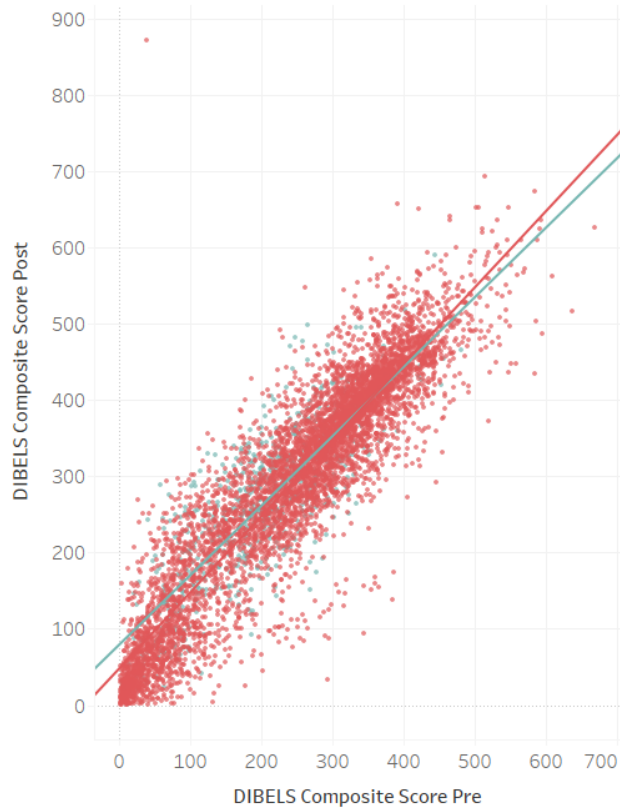




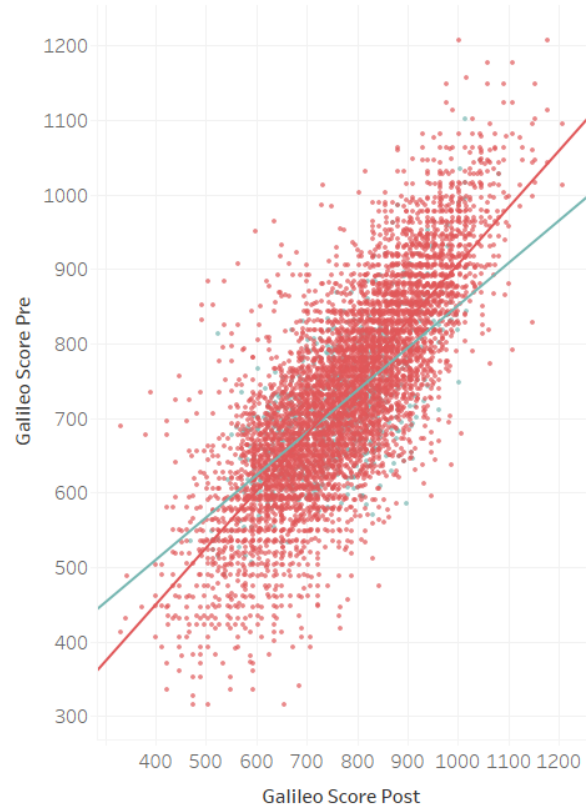
These stats are for the RBBB dataset I will be using. I'm currently updating the 2022 data which only has half of the year so far. The pie chart shows all RBBB participants (6436 total). The program has an overwhelming number of Hispanic students.

Participate
 ■ Non RBBB Student
 ■ RBBB Student

DIBELS

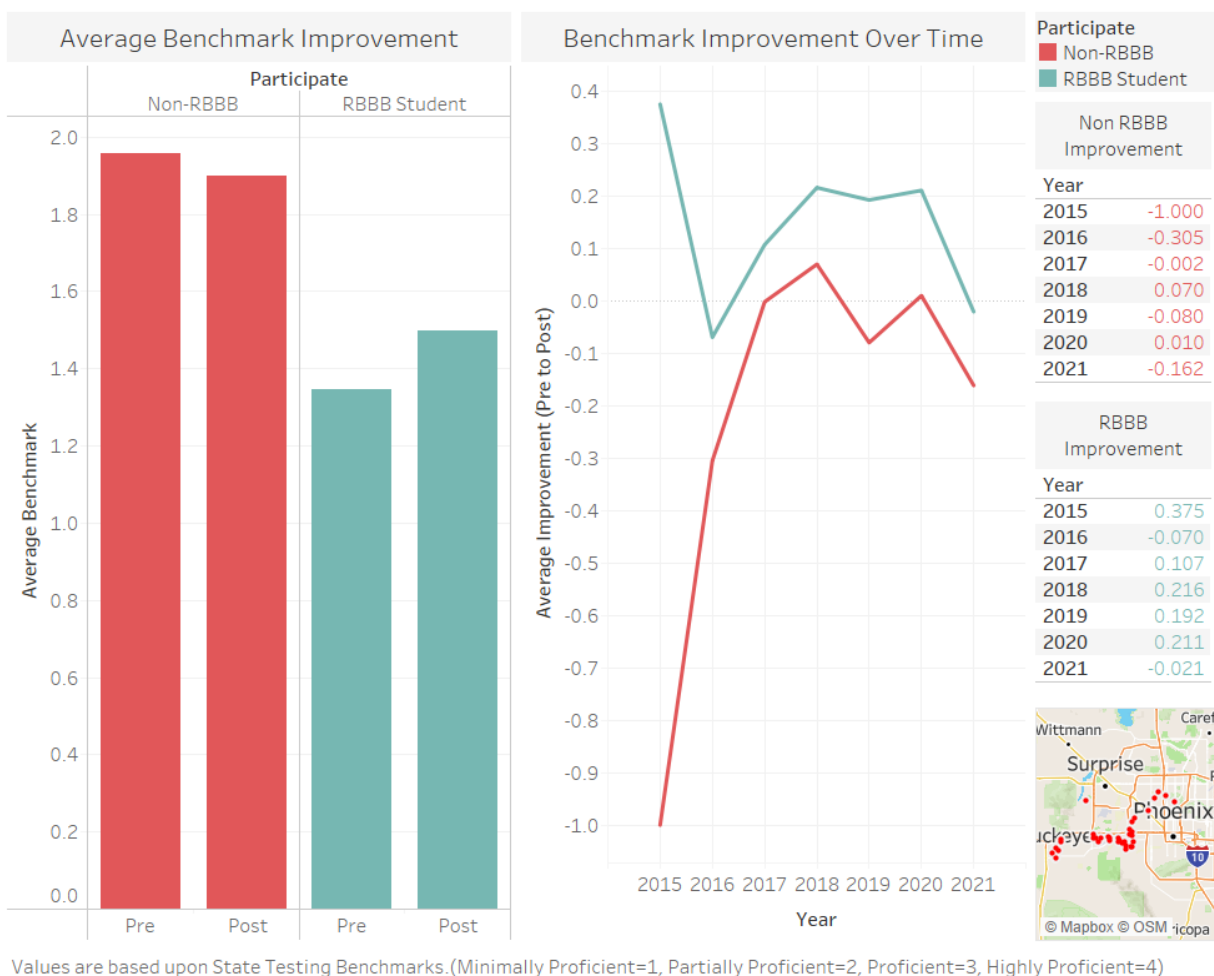


Galileo



These two graphs finally take a look at the RBBB students. The schools use different standardized tests to score their students. I'm looking at the tests with the largest samples to analyze trends. Both of the ELA 3rd grade tests resulted in the same pattern. RBBB helps students who are struggling to improve their scores. Students who participated in the program saw better post scores if their pre score was low. However, the effect of RBBB started to drop with higher achieving students. Most of the students who achieved the highest post score did not participate in RBBB and already had a high pre score.





The improvement is very clear among the third graders in RBBB. Their test scores consistently showed a better difference from the beginning to end of the year. Many students actually end up doing worse by the end of the year in the schools RBBB works in, but RBBB prevents this from happening.

Methodology

Data

To answer each question, I will be pulling from two datasets that have been modified:

The first dataset being used is pulled from the Arizona Department of Education. They provide test scores for all Arizona students based upon benchmarks. Students are graded upon their percentile compared to the previous year (0 - 40 Minimally Proficient, 40 - 60 Partially Proficient, 60 - 80 Proficient, 80+ Highly Proficient). Unfortunately each district uses different standardized tests. These dataset includes subgroups such as ethnicity and free or reduced lunch.

To analyze the income demographics of students, I don't have any way to get an exact number for particular students. Instead I will be creating another column in the Test Scores with the students zip code. I will be using the average income from the Census Bureau. They provide median and average household incomes.

The Arizona Department of Education also provides data on the district budgets. All public schools are required to submit this information. Their datasets contain money spent in categories such as employee payroll, supplies, and transportation. I joined this data with the test scores to look at average money spent per student as well as teacher salary/experience.

The second dataset is collected by RBBB. Read Better Be Better requests data for third grade students for every district. The data includes students with their name and pre and post test scores. So far the company is waiting to receive more scores, but there is data from about 15,000 third graders in Arizona. This includes data from previous years (Since 2019) leaves around 60,000 observations to work with. The data includes students from every school that the program works with, whether they were in RBBB or not. RBBB sends out surveys to participants as well as their parents and teachers. They also collect the same subgroup info such as demographics and F/R lunch. The organization operates mostly in central and northeast Phoenix.

RQ: Do reading scores correlate with the average income of the county? Free or Reduced Lunch? Demographics? District Spending?

To answer the first part of this question, there are two measures that can be looked at. There is no way to see parent income for each student, so we can only use the zipcode income, and whether or not the students' lunch is reduced or free.

For both county income and district spending, regression provides a basic understanding if there is a correlation with income and reading scores. Regression showed that income only has a tiny effect on the score of a student. The R value was only .535 so further investigation is needed.

I decided to then compare the difference between a student who has a Free or Reduced lunch. This is a much better way to identify students with lower income because parents can only qualify for this if they are in poverty. Using regression again, regular students had nearly double the influence on passing rates. This had an adjusted R squared of .68 as well so the model was fairly accurate.

Coefficients	Estimate	P value
Normal Students	.4269	>.0001
F/R Students	.2334	>.0001

I continued the research with K nearest neighbors classification on free or reduced students.

This time I compared the amount of students being tested to those who passed. This accounted

for the amount of students in each group as there are less students in poverty. The model showed that kids with a reduced lunch were passing at much lower rates:



Predict	Full Price (0)	Reduced Lunch (1)
Full Price (0)	4164	1578
Reduced Lunch (1)	1688	2674

67.7% Accuracy

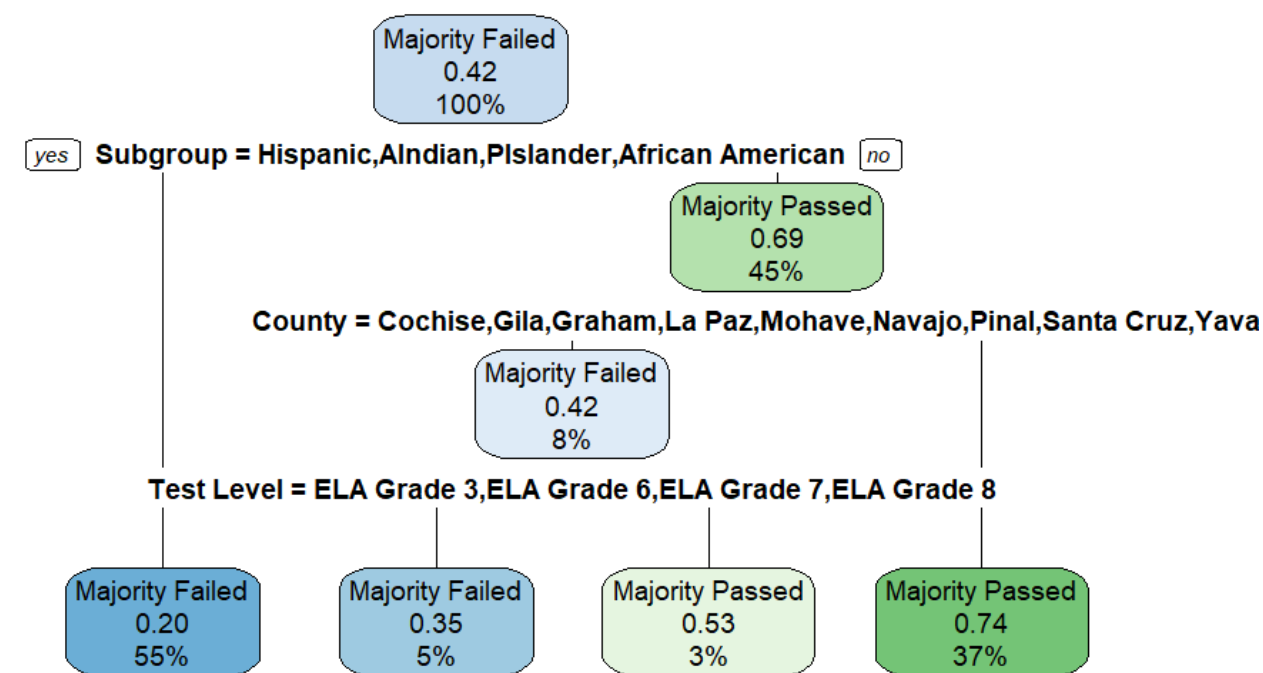
Next was to figure out if demographics or district spending was having an effect on students. I started with variable selection techniques, stepwise and lasso regression.

```
(Intercept)      5.907818e+01
White            1.809384e+01
Hispanic         .
AfricanA        -9.402351e+00
AIndian         -1.097369e+01
Asian           3.019798e+01
PIslander        .
City            2.170871e+00
```

Town	8.511399e-01
Suburb	-1.542675e-03
Rural	-6.410440e+00
PovertyRate	-7.311840e+01
SpecialEd	-9.484291e+01
StudentSpending	-2.143864e-04
TeacherSalary	4.055358e-06
InstructionSpend	1.712492e-03
CSF	-5.241538e-04

Using the model with the best Adjusted R squared showed just how much ethnicity determined reading scores. Through these models, I discovered that teacher salary and student spending actually had very little impact on score. In addition the location of students didn't actually matter all that much. Poverty rate and the Special Education population had a huge effect on the amount of students passing though. In addition, being white or asian resulted in a massive increase in the ability to score in the 60th percentile. This model left out charters schools as well that have much larger white and asian populations.

I wanted to investigate the difference in race with a classification tree that included the charter schools. The tree showed the extent of the difference between Asian and White students. They were more than twice as likely to pass an exam. There were extremely high pass rates for Whites and Asians in cities (Tucson, Flagstaff, or Phoenix) whereas location didn't matter for other races.

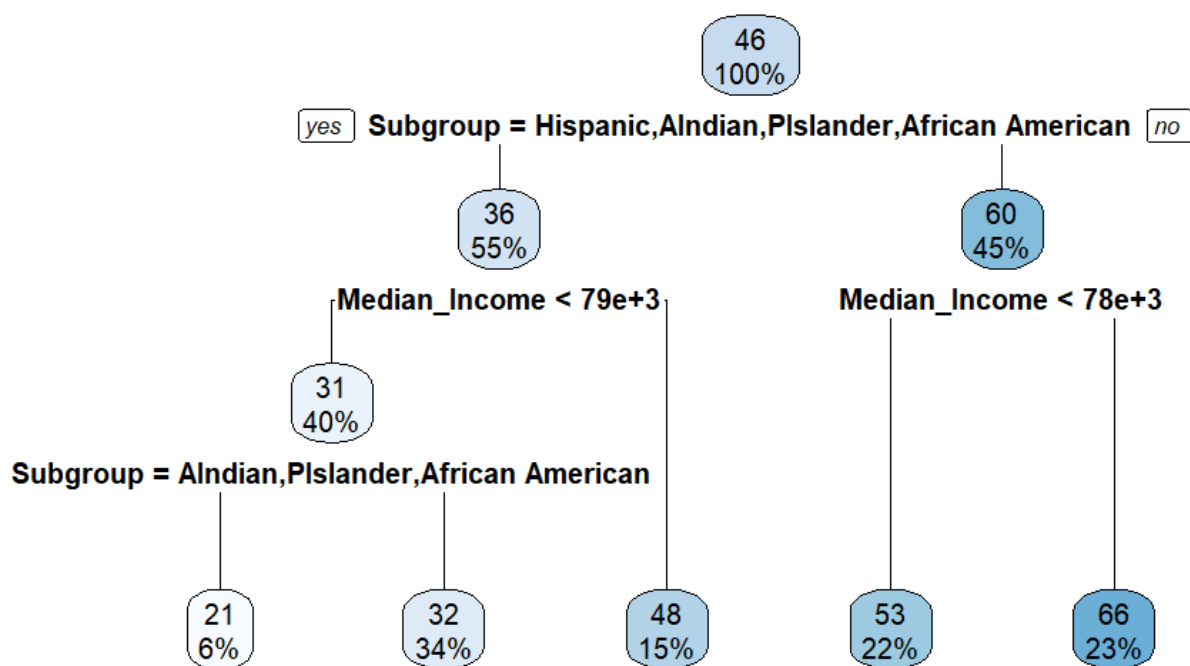


```

Majority Failed Majority Failed Majority Passed
Majority Failed 4662 1068
Majority Passed 1257 2922
[1] 0.7653648

```

I then used a regression tree to see if income and race played a role with each other which was once again more than 75% accurate. This showed that high income areas once again had ever higher White and Asian pass rates. This also gave a better perspective to the hispanic population. Hispanics performed better than other lower income minorities.



RQ2: What predicts the most improvement in reading scores based on survey answers?

How well does Read Better Be Better improve scores?

The survey answers are based upon a scale and therefore it will be useful to still use regression techniques as well. Both stepwise and LASSO models will be effective in locating the questions that correlate with a better difference in pre and post scores. This LASSO model will be run with multiple test and training sets with 50% subsamples. This will help with overfitting the model.

The stepwise will be run multiple times and use the model with the least amount of variables with the highest Adj R squared and ROC curve. In SAS, I discovered that very few of the survey questions actually provided any sort of insight. Questions that dealt with self esteem such as "Do my classmates think I am a good reader" had the best prediction of score. Overall, there is just too few students in the program for this to be insightful.

For the second part of this question, it starts with some data prep. Many districts over the years have used different standardized reading tests to evaluate students. However, they all group students into four categories: Well Below, Below, Proficient, and Highly Proficient. In order to see improvement then, I converted the three most used testing metrics to their benchmark groupings.

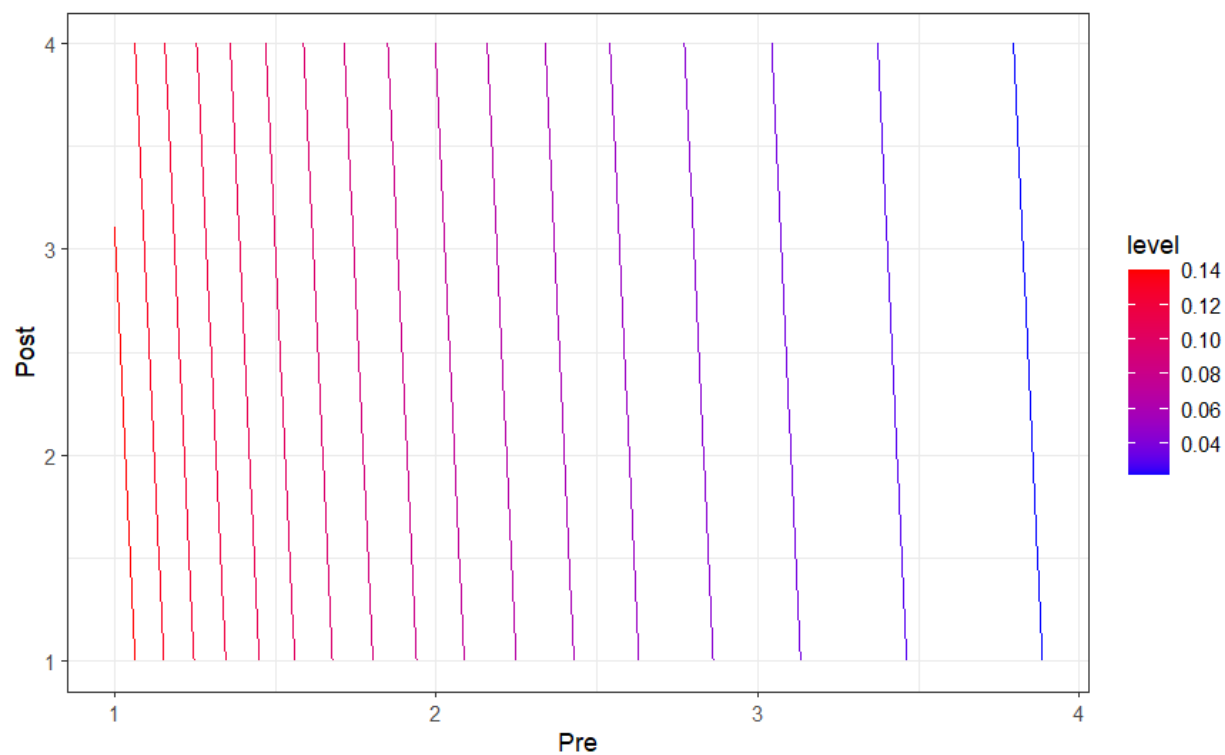
I decided to start evaluating the impact of the program with another regression. I used the difference in their pre and post benchmark to see if the student improved or got worse.

```
Estimate Std. Error t value Pr(>|t|)
(Intercept) -0.057305 0.008461 -6.773 1.31e-11 ***
Participate 0.211262 0.026909 7.851 4.43e-15
```

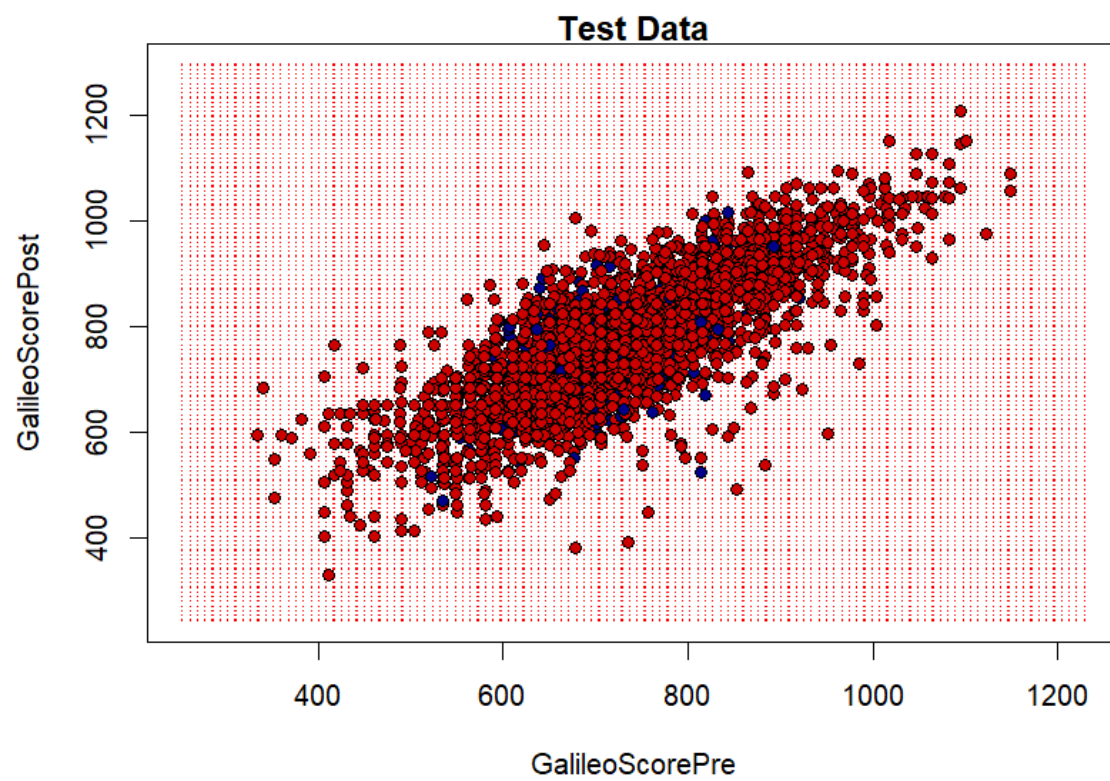
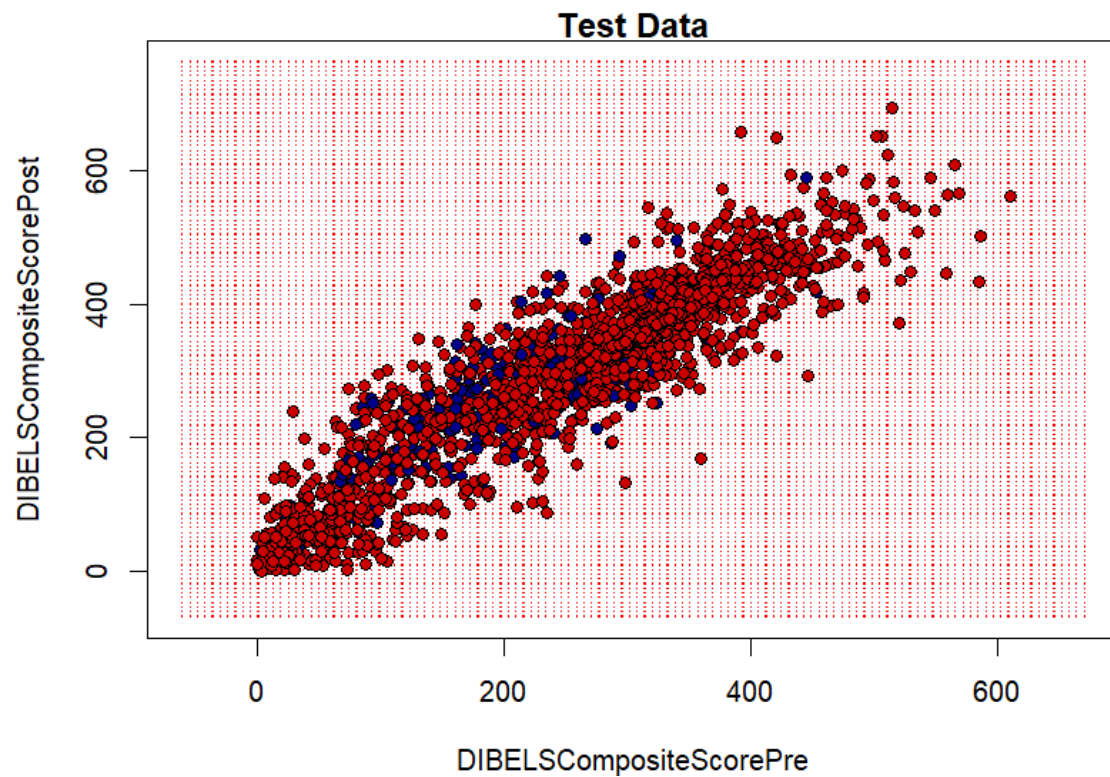
Whether or not a student at the schools RBBB operates in was in the RBBB was very significant to judge improvement. Clearly RBBB helps students achieve better reading comprehension.

I then used logistic regression to guess if a student was in RBBB based on pre and post scores. The model wasn't as accurate, but it showed that RBBB students were much more likely to start with a worse score, even though the data only includes schools they operate in. RBBB students are most likely to be in the category of a very low Pre score and high Post score.

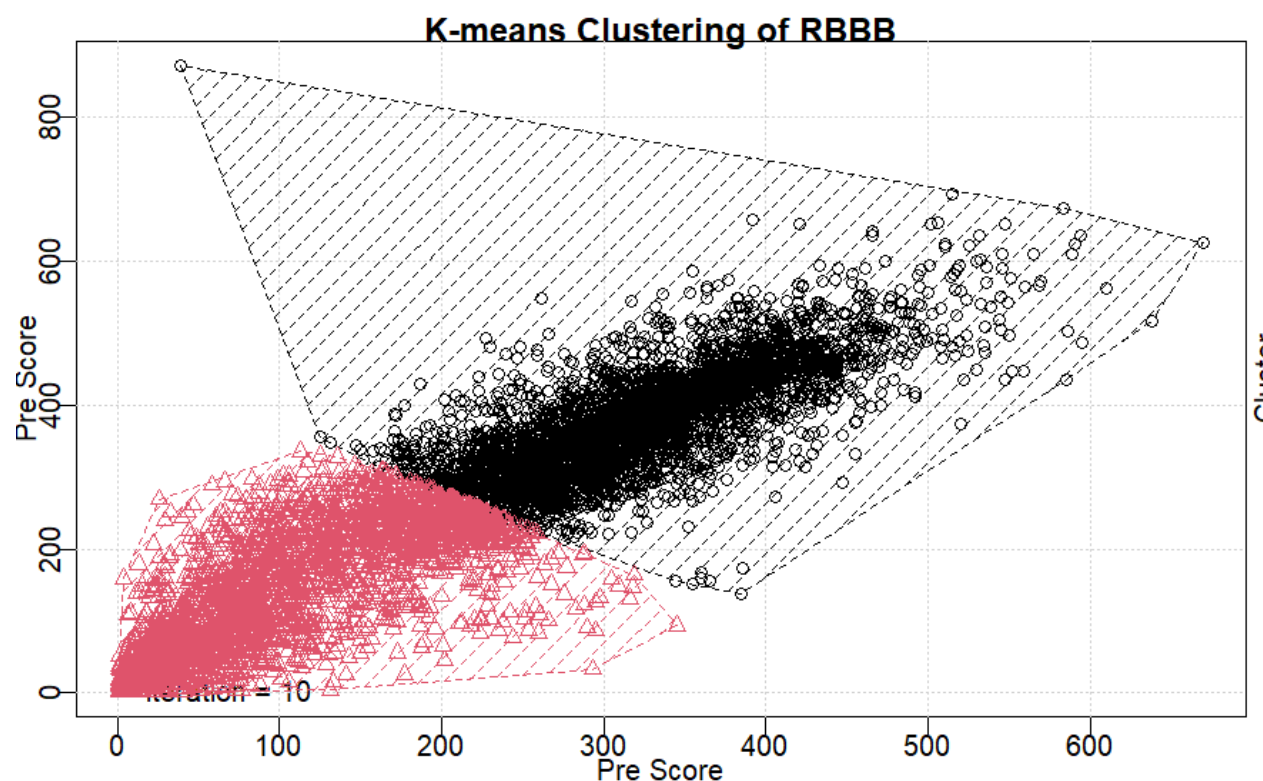
```
Estimate Std. Error z value Pr(>|z|)
(Intercept) -1.05036 0.06504 -16.150 <2e-16 ***
Pre -0.69973 0.04718 -14.831 <2e-16 ***
Post -0.02097 0.04029 -0.521 0.603
```



Next I attempted classification techniques to see if machine learning could identify the difference between RBBB and regular students. I started with Naive Bayes classifiers with the two most prominent testing methods: DIBELs and Galileo. Both of these Naive Bayes were unable to identify any difference between the groups. As it stands, there is not enough RBBB students to guide this particular model.



Consequently, I switched to clustering to try and identify a difference. Using the DIBELS pre and post test scores did end up showing a difference this time. After 10 iterations, K means clustering was able to break down the RBBB students. As previously shown, the RBBB students have lower beginning of the year scores but a higher slope than their peers.

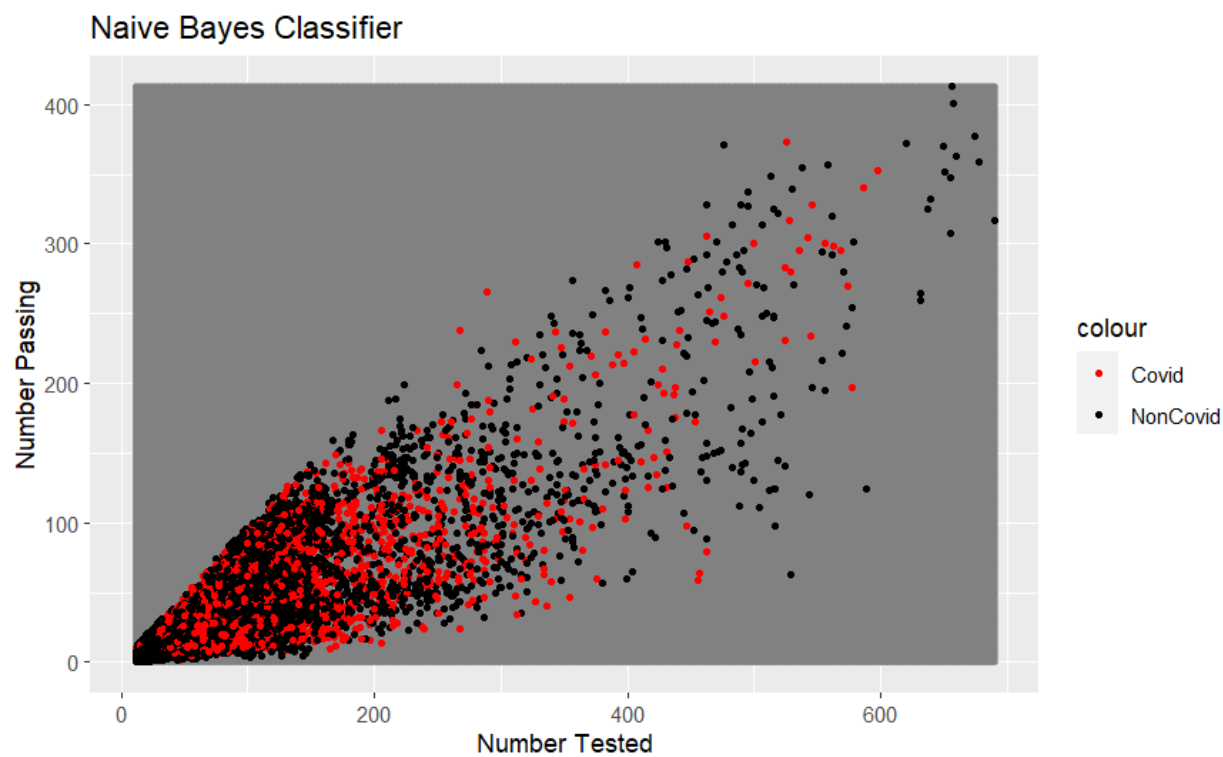


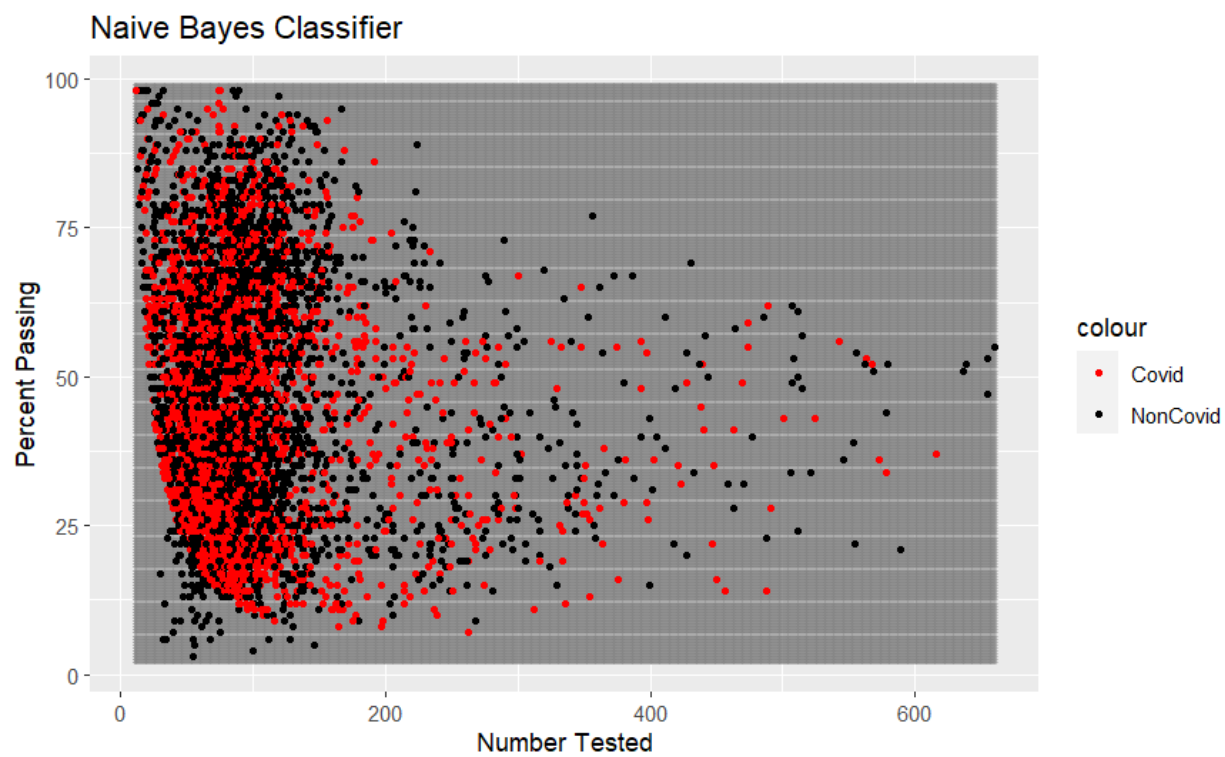
RQ: How has education been affected by covid?

Using a Gaussian Mixture Model did indeed identify a difference between the distributions in 2017-2019 and 2021-2022.

I used a Naive Bayes classifier to see if there was a difference in passing rates but no matter what parameters I used, there was not enough difference between Non covid and covid years. In the second graph I compared 2019 to 2021 and still the naive bayes was only able to put the data under one classification. In Arizona, the reading pass rate only dropped by about 3% but

that was very similar rates to 2017 and 2018. As a result, in Arizona there is not enough statistical evidence to say that Covid had a significant effect on reading test scores.





Ethical Dilemma

The main issue when evaluating test scores is that it does not fully reflect learning. Academic success also relies on your ability to work with others. Testing students is our best attempt at quantifying student growth academically. Students often have anxiety while taking tests, some run out of time, and many students don't try their hardest. 40-60% of students admit to having test anxiety at some point or another and around 38% record having it all the time (Morton). It is impossible to factor in all of these factors. However, we can see that there is more variance when students reach middle school. The model cannot explain exactly why middle schoolers are performing worse. It's important to refrain from characterizing the results from the models as the overall learning.

The testing curriculum itself presents perhaps the biggest problem with the data. There are portions of the tests that aren't purely objective. For example, the oral DIBELs test has a list of checkboxes to fill out. Students can be marked off for failing "Reads with appropriate phrasing, intonation/expression, and observed punctuation." A few questions are subjective like the ladder. Worst of all, all of these oral DIBELs tests are graded by a different teacher depending on the class. Our results have plenty of errors because of this, but there can also be a bias against certain types of students. Some of these students are first generation English speakers or have different accents. A teacher may mark off points to these students with a thicker accent.

We must also consider that the Read Better Be Better test scores contain a biased sample. The students in the program are not likely to be higher performing students. The vast majority of the target schools are lower income and therefore have worse test scores to begin with. This biased sample may have a positive or negative effect on the improvement of students and it's not possible to decipher from my current data. Lower performing students may see more

improvement because they miss so many questions on the first tests. Some high performing students can't improve their test score beyond a few points because they barely missed any questions. Another variable to consider is the type of parent these students have. Third graders are not enrolling themselves in the Read Better Be Better program. The parents who choose to enroll their child are likely more attentive to their child's learning. As I mentioned earlier, the environment of the student matters most when determining a test score. Read Better Be Better is providing a learning environment for students regardless but the scores could be slightly inflated because of this.

At the end of the day, the impact of Read Better Be Better is clear improvement. Even if the improvement of the program is slightly boosted or hindered by the type of students in it, that is better than no program at all.

Challenges

Most of the challenges are issues with the data itself. As mentioned earlier, the Read Better Be Better data only contains test scores without a scale for whether a student is “Proficient”, “Highly Proficient”, etc. This meant that I had to test multiple times with the different assessments districts use. In addition, the Read Better Be Better dataset unfortunately doesn’t have many entries yet. The organization was created in 2015 and therefore many of the models were inaccurate. In addition the organization primarily operates in lower income areas where improvement in test scores isn’t as common. Covid was a massive problem as well. I tried to answer this question but there are so many variables that are unmeasured. For one, no tests were actually done in 2020. To make matters worse, both 2021 and 2022 had significantly less testing. The largest factor that is still up in the air however is the online testing that was done. Many schools switched to hybrid formats and used online testing which opened the door for students to cheat. There is no way to measure this yet 2022 had seemingly normal scores. Online may have allowed less learning but more cheating, there is no way to know from the data I have.

Recommendations

The obvious problem of economically challenged communities underfunded schools must be addressed. Many parents consider long commutes just to put their children in a better school. The problem with poor households performing worse in school creates a detrimental cycle. This continues the gap in income inequality and race. We saw how stark the difference is currently in race pass rates in Arizona. While schools only provide a few benefits such as reduced lunch, it is in the best interest of organizations like Read Better Be Better to target these children. An emphasis should be placed on schools with a higher percentage of Free/Reduced lunch students.

As for Read Better Be Better, I think the program is doing fine. Students and parents have been reporting more enjoyment in reading. The test scores definitely do improve, although only by a little amount. However, the small change in test scores pales in comparison to the future enjoyment of learning that the program provides. Parents should not expect a sudden rise in test taking ability especially because a student's speaking ability cannot be judged with a score.

From the data on recent test taking, schools need to be implementing better cheat detection. There is way too much increase in test scores in 2022 and that can only be accredited to the online format. High schools and colleges are much better at preventing this with lockdown browser but as it stands, the elementary and middle school test scores are not representative of a student's capabilities.

Going forward I think for one, Read Better Be Better should record more data such as books read, whether or not they had the same Reader/Leader, and ditch a lot of the survey questions. I think it would also be useful if the districts recorded whether or not a test was taken online.

Appendix

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	85.66780	20.18797	51904	18.01	<.0001
DIBELSCompositeScorePre	0.88453	0.03607	1733161	601.29	<.0001
SEpre5	3.70410	2.33425	7258.15954	2.52	0.1137
SEpost16	8.88123	3.35994	20139	6.99	0.0087
SEpost17	-8.39387	3.94300	13062	4.53	0.0342
SEpost18	7.48750	4.10409	9593.87667	3.33	0.0692
SEpost19	7.34980	3.14221	15770	5.47	0.0201
SEpost21	-7.69076	3.32434	15427	5.35	0.0214
SEpost29	-1.97703	1.27747	6903.61458	2.40	0.1229
SEpost30	-6.99173	3.50448	11473	3.98	0.0470
SEpre31	6.07963	3.45232	8938.95114	3.10	0.0794
SEpre32	-7.08761	3.23993	13794	4.79	0.0296

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