

A Computational Analysis of the Lewiston Public School System

David Akinyemi, Juliana Martino,
Elizabeth Johnson, Zach Farhm

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Industrial Problem

The Lewiston Public School (LPS) district is one that enriches, supports and educates students in the Lewiston, Maine community. Ranging from the elementary to high school level, LPS serves roughly 5,000 students with more than 600 certified and support staff members [1]. The Lewiston school district consists of six elementary schools, one middle school and one high school as well as a technical center. When we were approached by our LPS liaison, the Continuous School Improvement Coordinator, Kate Barcellos, she explained to us that as LPS is currently transitioning from proficiency based learning (grading on a scale of 1 – 4) to percent and letter grades (grading from 0 – 100) and she is adjusting to her new position, she would love to receive any and all analysis that we can complete on the district. She had no concrete problem or question but spoke about wanting to gain insight into process data that compared schools within LPS to each other and other Maine school systems in regards to disciplinary statistics, standardized testing scores, graduation rates and much more. With such an open-ended project, the opportunities for research were immense. Based on our conversation with Kate and our experiences with working at many schools in the district, we chose to focus on three areas. We deemed these areas the utmost important because these analyses could evoke systematic change and cause additional financial support to areas of the district. We decided to computationally ask and research the following questions in hope that the answers would best help Kate focus additional resources within the LPS district:

- What population, disaggregation information and school location strongly correlates with behavioral issues and overall assessment achievement levels?
- How do schools compare across Lewiston in terms of achievement levels?
- How does the Lewiston Public School system compare to the other larger school systems in Maine?

Each question was examined in different ways but all were incorporated for us to gather our final results.

Results

We obtained our data from the Maine Department of Education’s online ESSA (Every Student Succeeds Act) data dashboard [2]. This data contains non-identifying statistics on how different schools from different districts in Maine performed on Science, Math, and English Language Arts (ELA) test subjects for the academic years ranging from 2015-2016 through 2018-2019. This data set includes the details of the students’ demographics as shown in Table 1. It also reports the students’ achievement levels in comparison to state expectations. There are many holes in the data, however, and for some cases we can only analyze students performing in the two categories of ‘At or Above State Expectations’ and ‘Below or Well State Expectations’. Within this data set there is also information regarding behavioral incidents in all schools as well as graduation rates for the high schools in select districts.

Our original goal was to create a predictive model that could show the success or failure of a student based on population indicators. We analyzed many indicators including graduation rates,

behavioral statistics, and assessment performance. We quickly realized that it was nearly impossible to predict a student's success or failure given a few basic population indicators. While we continued to investigate a predictive model, we also attempted to portray an accurate and current picture of the school district as a whole. We completed the computational analysis of this problem in Python using packages such as, matplotlib, pandas, seaborn and numpy.

Type	Descriptor
Schools	Farwell Elementary School Martel School Montello School Lewiston High School Thomas J. McMahon Elementary School Lewiston Middle School Governor James B. Longley Elementary School Raymond A. Geiger Elementary School
Population	Economically Disadvantaged Black or African American All Students Native Hawaiian or Other Pacific Islander Asian White Homeless Hispanic or Latino Two or More Races Female English Learners (Monitoring) Male English Learners American Indian or Alaska Native Students with Disabilities Students in Foster Care Migrant Parent in Military on Active Duty
Disaggregated	Other Racial/Ethnic Diversity All Students Sex
Assessment	Mathematics English Language Arts Science

Table 1: Data set variables

What population, disaggregation information and school location strongly correlates with behavioral issues and overall assessment achievement levels?

We converted the qualitative achievement level rankings into a quantifiable spectrum as seen in Table 2. Once this transition was made, we then created a new data set converting all the quantitative information into dummy variables to see what variables were correlated to one another. Figure 1 is the correlation matrix showing all the components of our data set correlated to itself using the seaborn package and its built-in `Corr()` function. This heat map representation of our data set showed no meaningful correlation between indicators.

Achievement Level	Allocated Value
Well Below State Expectations	0
Below or Well Below State Expectations	0.5
Below State Expectations	1
At State Expectations	2
At or Above State Expectations	2.5
Above State Expectations	3

Table 2: Quantitative scale for achievement levels

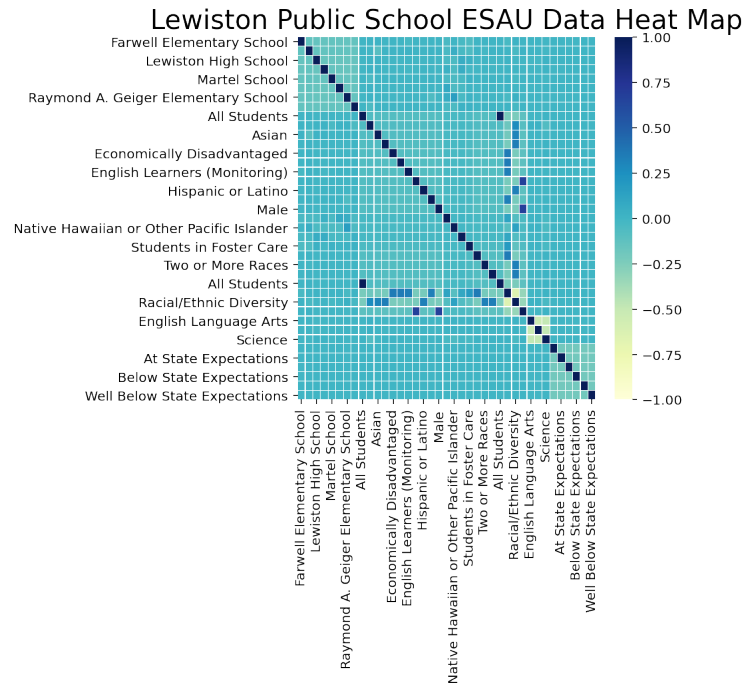


Figure 1: A heat map created from our initial descriptors data set

We chose to focus on regression, predictive and machine learning models that would factor in the entirety of the data set to reveal trends and strong correlations despite our heat map's

insignificance. We started by creating a linear regression on our data set and though unsatisfactory, we found it to be very pivotal in our next steps. We chose to run many different machine learning models and regressions, using 20 % of our data to train each model. We used Linear Regression, Logistic Regression, Support Vector Machines (SVC), k-Nearest Neighbors, Gaussian Naive Bayes, Perceptron, Linear SVC, Stochastic Gradient Descent, Decision Tree and a Random Forest Classifier as models for predicting how well students would perform based on their school and demographic disaggregation. Our best performing model was the Decision Tree with 21.79% accuracy. Figure 2 provides an example of how it worked on a random sample of 20 student characteristic combinations.

Lewiston Public School Decision Tree Predictive Model on Random Sample Size of 20

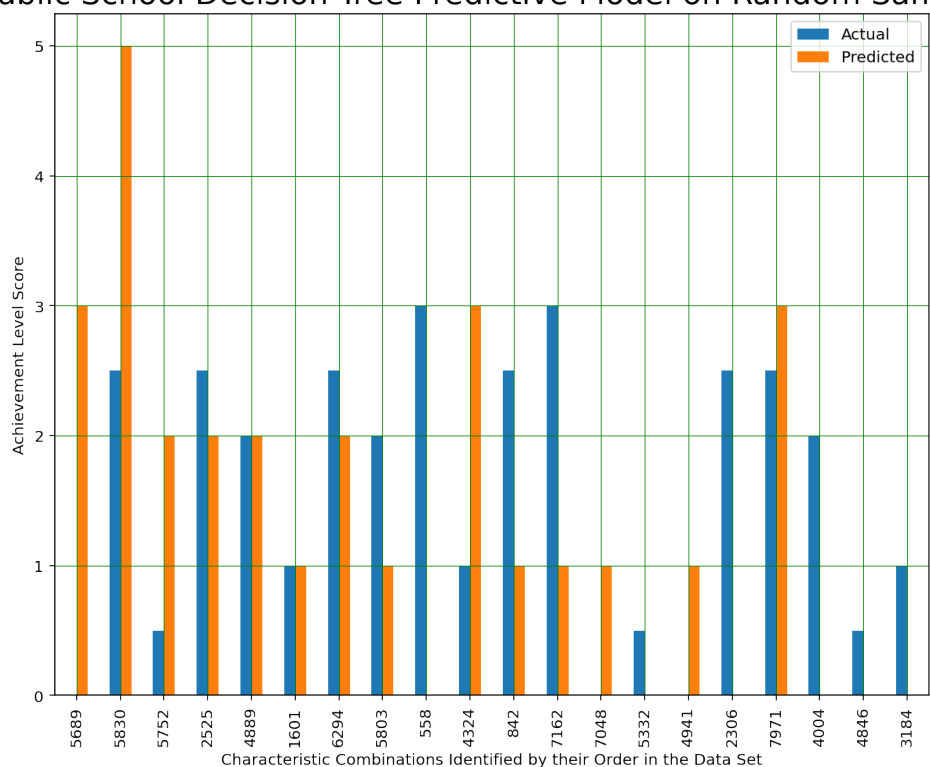


Figure 2: The Decision Tree predictive model on 20 random description combinations

We found that our top models were the three that used machine learning; the Decision Tree model, the Support Vector Machines and the Random Forest Classifier. Table 3 shows the accuracy of each method. Though our top three models all had a small accuracy of around 20%, we saw a common theme in how each method weighted the specific categories in our predictions. We found that all three of these tops methods strongly correlated attending Raymond A. Geiger Elementary school with a student’s success. We found that our best machine learning tool, the Decision Tree predictive model, was able to predict a student’s achievement level with 21.79% accuracy. Although this model is clearly far from perfect, we tried to work with what information it gave us. Of all the variables factored in to this prediction, the Decision Tree allocated its highest weight of 10.17 % to whether or not a student attended Raymond A. Geiger Elementary School. This insight led us to further investigate what aspects of Geiger Elementary could give it such precedent in achievement compared to the other schools in the Lewiston district.

Rank	Model	Score
1	Decision Tree	21.79
2	Support Vector Machines	20.45
3	Random Forest	20.02
4	Logistic Regression	18.30
5	Linear SVC	18.22
6	Naive Bayes	18.05
7	KNN	17.98
8	Stochastic Gradient Decent	16.90
9	Perceptron	16.87
10	Linear Regression	0.07

Table 3: A table ranking the models used and how well they scored

How do schools compare across Lewiston in terms of behavioral conduct and achievement levels?

Our initial approach to the behavioral data involved totaling all of the write-ups for one year amongst all different categories of write-ups. In order to contextualize this data, we created a ratio of behavioral write-ups to total school enrollment. We found that Geiger Elementary School has the lowest percentage of write-ups and Lewiston Middle School has the highest percentage for the 2018-2019 academic year.

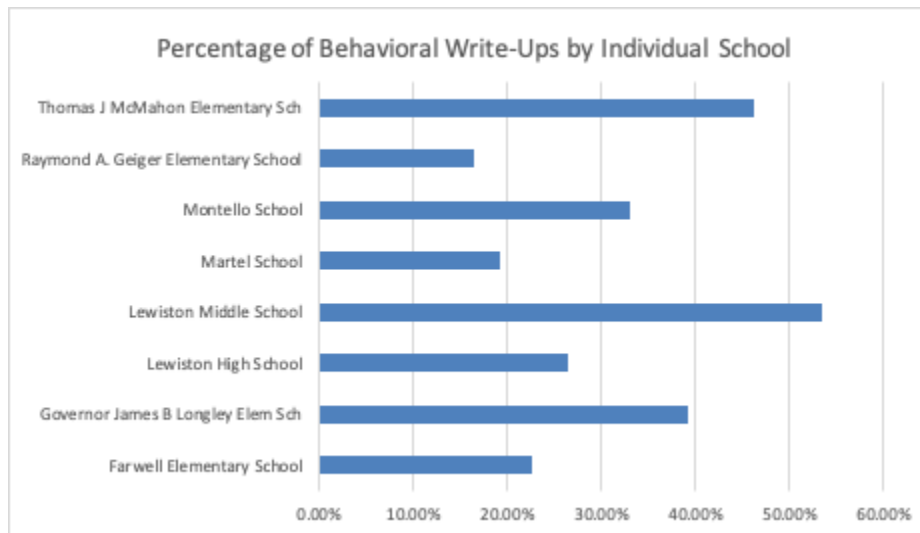


Figure 3: Behavioral write-ups at the eight schools in the Lewiston Public School district.

We further investigated the differences between the schools in Lewiston by observing the test performances in each individual school. Doing so we continued to observe Geiger Elementary's dominance over all other elementary schools in the district. Figure 4 clearly shows this school has the highest number of students scoring at and above state expectations. Farwell Elementary is a close runner up especially in regard to English and Science exam subjects.

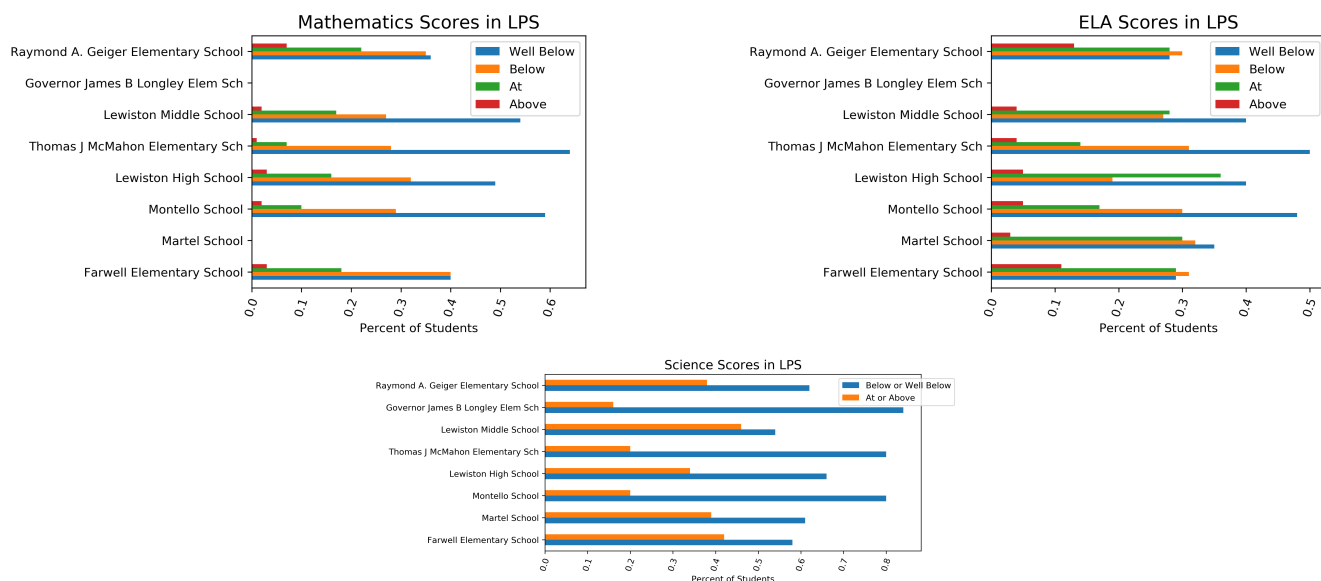


Figure 4: Mathematics, English and Science scores by individual school in LPS

Another significant finding from Figure 4 is the strength of Lewiston Middle School in the Science subject. This could indicate a stronger science curriculum in this school compared to the elementary schools and high school and could be something our industrial liaison would want to look into. Unfortunately, due to incomplete data we do not have information regarding student performances in these four categories for Longley Elementary in Mathematics and ELA tests and for the Martel School in the Mathematics test.

Given the large number of Somali refugees and English learners in Lewiston, we did not expect to see students scoring higher in English Language Arts than in Mathematics. This could be due to a more rigorous curriculum in English that has been implemented due to the unique population in Lewiston as well as potential neglect concerning Mathematics studies in the schools.

How does the Lewiston Public School system compare to the other larger school systems in Maine?

When comparing the Lewiston Public School district to other school districts in Maine, Lewiston stood out amongst all categories. In terms of behavioral issues, Lewiston Public Schools ranks significantly higher than most other schools. This trend can be seen in Figure 5, where the behavioral tallies are taken as a percentage of their total enrollment. We represent our data in terms of percentages in order to discredit the varying student enrollment from district to district.

The Lewiston Public School system is the second largest district in Maine. As we narrow our investigations, we will compare Lewiston to the largest district, Portland Public Schools, as well as the third largest district, Bangor Public Schools. In the 2018-2019 academic year PPS had a total enrollment of 6,796 students, Lewiston had 5,493 students and Bangor had 3,749 students [2]. It is important to give an accurate representation of each population in these major districts. Pie charts describing the students required to test in each district can be seen in Figure 6. Due to Maine's "opt out" policy, students are allowed to excuse themselves from taking these standardized tests with

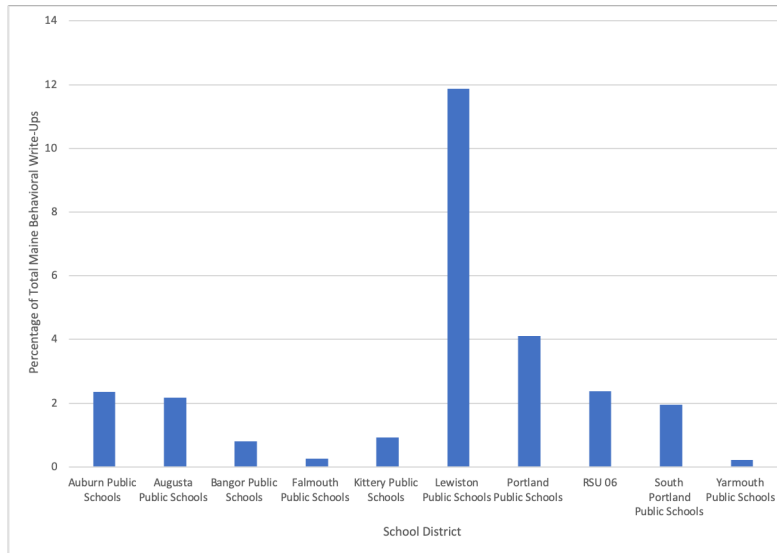


Figure 5: Percentage of behavioral write ups compared to the total enrollment

parental/guardian permission [3]. This is why the total number of students required to test, seen in the bottom right-hand corner of each pie chart, differs greatly from the districts total enrollment numbers. All three districts consist of a white majority, with Bangor being significantly less diverse than Lewiston and Portland. Lewiston has the largest number of Black or African American test takers out of all three districts.

The next step in our analysis was to see how the achievement levels correlated with one another through a correlation matrix using Python’s seaborn package. This tool will hopefully show an overview of test performance for the three major subjects: Mathematics, English Language Arts (ELA) and Science in Lewiston as well as Portland and Bangor. Figures 7, 8, and 9 show the comparison of Lewiston, Portland and Bangor’s test performances for the 2018-2019 academic year. These matrices show the varying levels of correlation that exist between doing poorly on an assessment in Mathematics, English Language Arts, and Science. This visualization tool is helpful in that it confirms that Lewiston students have a high likelihood of doing poorly on other subjects when they do poorly on one specific subject. Compared to Bangor and Portland, the relationship between doing poorly on two different tests is less strong in all cases, except in the relationship between Mathematics and ELA in Portland.

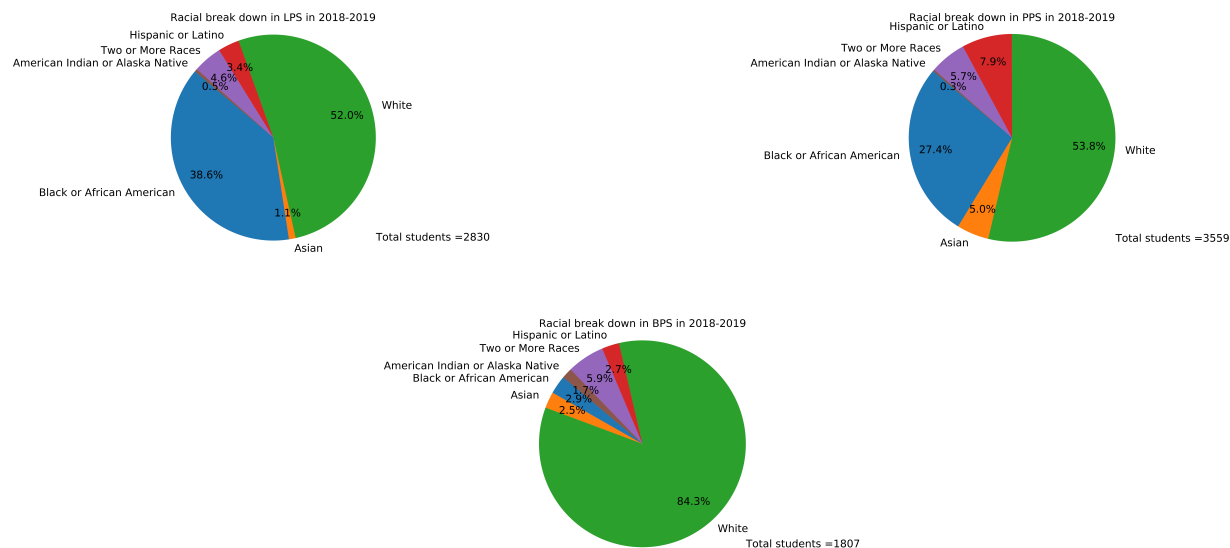


Figure 6: Racial breakdown of Lewiston, Portland and Bangor test takers for the 2018-2019 academic year.

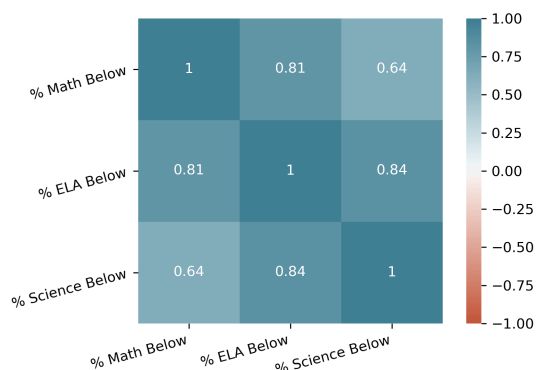


Figure 7: Lewiston correlation matrix

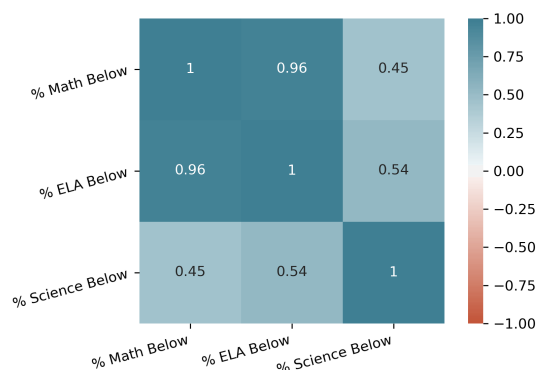


Figure 8: Portland correlation matrix



Figure 9: Bangor correlation matrix

Investigating further into Lewiston, Portland and Bangor test performances, we see that our correlation matrices were correct. Looking at the performance of ‘All Students’ in ‘All Schools’ in Lewiston in Figure 10, it is clear the majority of students are under performing compared to state expectations in all three exam subjects for the past four academic years. Students seem to score the worst in Mathematics and the best in Science.

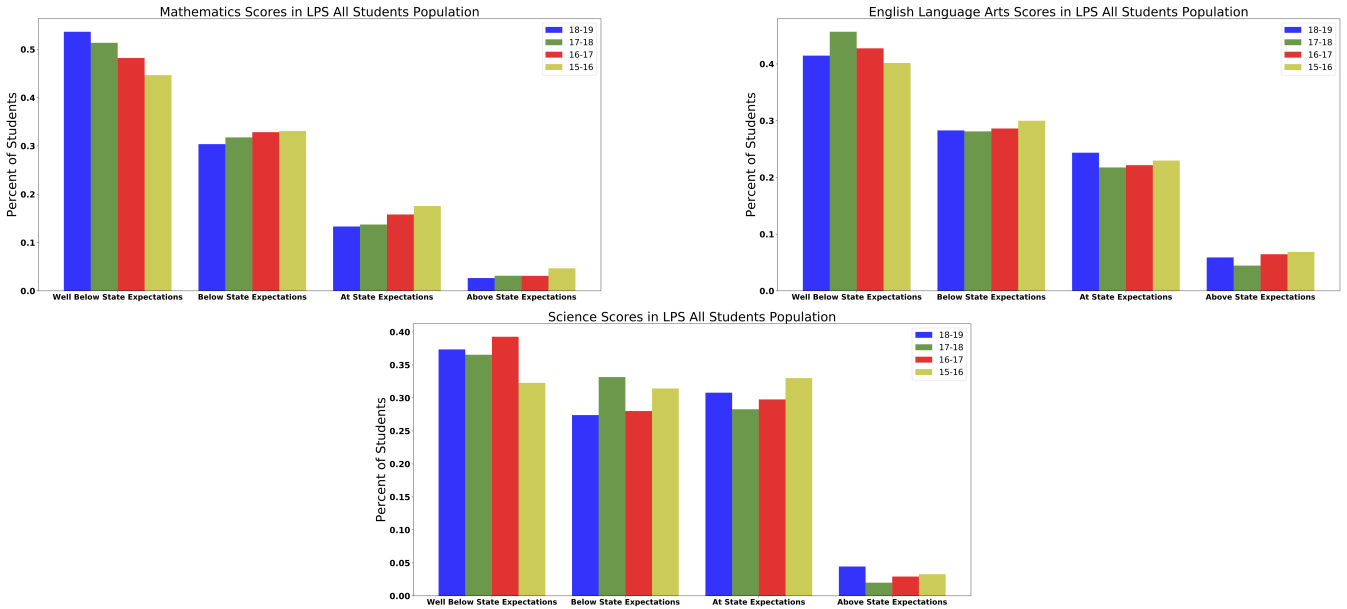


Figure 10: Test performance of students in LPS over the past four academic years

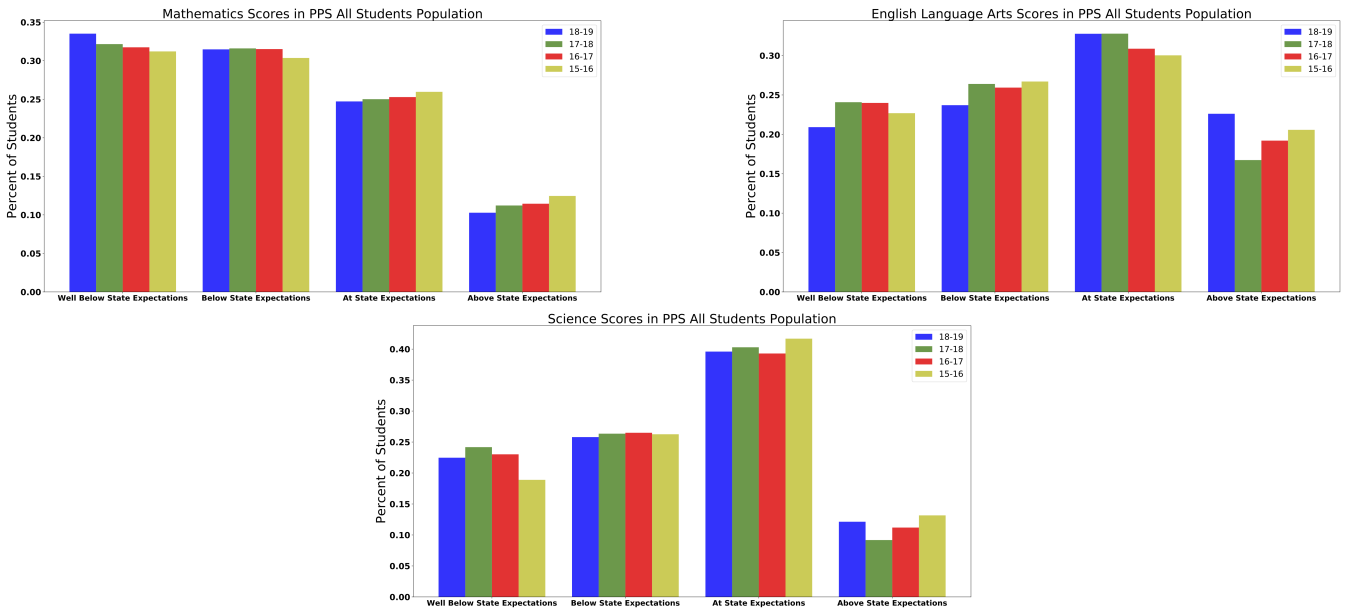


Figure 11: Test performance of students in PPS over the past four academic years

However, even students in Portland struggle with Mathematics as seen in Figure 11. Comparing

these two districts visually, we seen Lewiston is skewed heavily toward ‘Well Below State Expectations’ in all three subject matters while Portland tends to be more normally distributed, with a mean around ‘At State Expectations’, as one would desire for assessment data. The differences between these two districts could tell Lewiston educators to model their curriculum closer to that seen in PPS, especially in regards to the subjects of Science and English.

Looking at Bangor’s performances in the three subject matters in Figure 12, we see this district has success across the board. Over the past four academic year this district has had a relatively normal distribution of test scores in all three subjects. Something that is unique about this district, however, is the existence of Intermediate Schools. Bangor consists of ten schools, two of which are Intermediate Schools which consist of students in grades 4-5. This could be one potential factor to Bangor’s continuous success throughout the years.

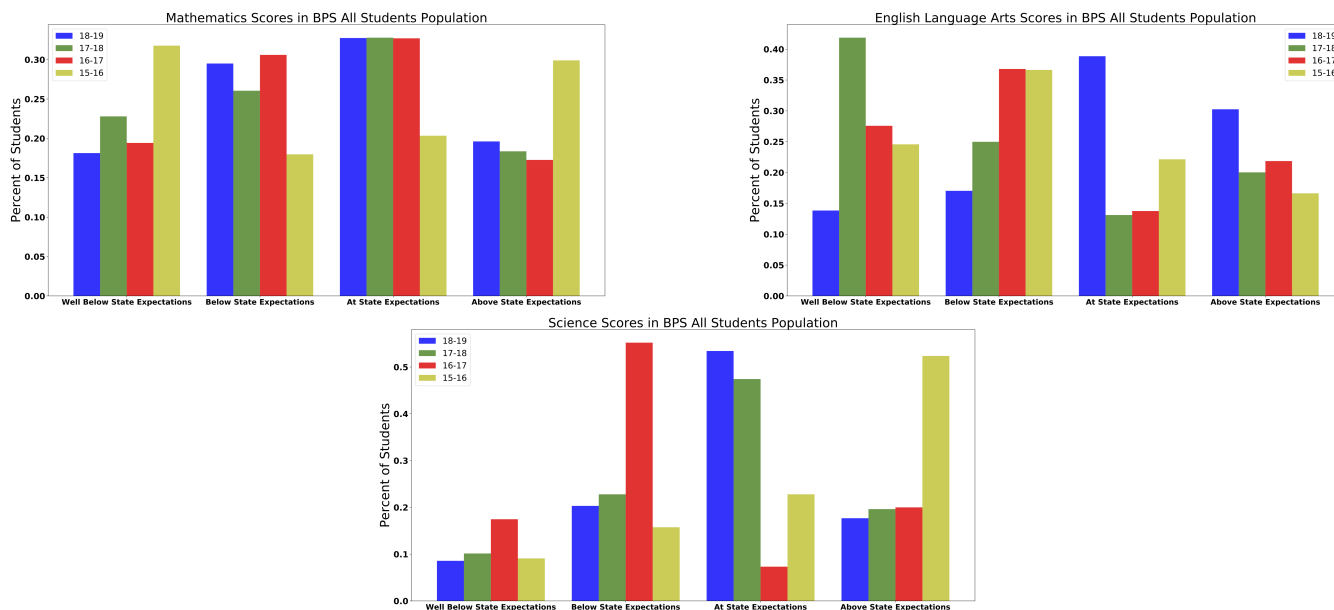


Figure 12: Test performance of students in BPS over the past four academic years

Conclusion

Overall, Lewiston Public School students are scoring below state expectations and this calls for immediate change whether that be seen in the curriculum, allocation of resources, or even a change in how administration deals with students behavioral issues. Geiger Elementary School has been proven to be the most successful out of all Lewiston schools in regard to test scores and behavioral misconduct.

We predicted with roughly 20% accuracy whether or not a student in Lewiston Public Schools will be successful or not. Education is a complex and multivariate subject, therefore we should not be able to accurately predict a students outcome. This 20% accuracy comes from the fact that attending Geiger Elementary is an indicator of academic success in the Lewiston district. This is an issue seeing an though student success should be equally distributed throughout the schools in the district.

Comparing Lewiston to the two other large districts in the state, we see that our students are greatly under performing and the answers to why this is happening may lie in the differences between the districts we have studied. That being said, there are a large number of differences that we barely investigated given the limited time of the semester. Again, education is a complex subject and a lot of factors must be considered. The goal of this project was to demonstrate the current standing of Lewiston Public Schools in comparison to each other as well as other similar districts in the state. We clearly see there exists an issue in the Lewiston Public School system and with this report we hope that our industrial liaison, Kate, has a few factors of interest in mind.

Moving Forward

In regards to looking at how Geiger Elementary differentiates when compared to the other elementary schools within the district, we hope that in the future another group of Bates students can create an in-depth analysis that focuses on how Geiger contributes to academic success versus academic failure. Currently we know that Geiger is correlated with student success, but we do not know exactly why. If we had more time, we would plan to work on a predictive model that focuses on what aspects of Geiger contributes to a student performing above or well above and a student performing below or well below expectations individually instead of how they perform as a whole. There are a variety of possible factors that could explain the uneven distribution of success throughout the Lewiston school district, some including: zoning, allocation of resources (i.e. teachers and financial assets) as well as racial and economic demographics.

In the future we hope to train our model of a much larger portion of data since teaching our model off small portions does not typically produce the most fulfilling and accurate results. This could be obtained by adding ESEA data from the past 10 years to get a more holistic view of this data and how it has changed over time. Moving forwards we would be interested in seeing what additional resources may have been provided at Geiger that perhaps were not offered at other elementary schools and how that translates to the new remote learning methods taking place because of COVID-19. We are also curious as to how having students switch to learning remotely and independently will affect their achievement levels in future years. Another helpful data set to access LPS performance would be nationally standardized tests such as the SAT and ACT. This will add to the overall analysis began in this project and hopefully shed light on other areas of possible improvement.

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