**AP Calculus BC – Data Narrative**

Kyle Coapman

kyle.d.coapman@gmail.com

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# Abstract

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# Teaching Context

I teach at North Star Academy Washington Park High School. My school is part of a greater network of schools in Newark (North Star Academy) and a greater network of schools in the north eastern United States (Uncommon Schools). Most North Star students attended the NSA middle schools starting in 5th grade, but we also have students who have transferred from different middle schools and high schools. *Add a blurb about demographics at NSA WPHS related to race and income.* Washington Park HS places a high emphasis on high expectations across all classrooms and cultivates a culture of success by routinely recognizing accomplishments through a morning forum of the entire school community.

This year, I had the honor of working with 30 students in their senior year of high school in the challenging course of AP Calculus BC. My sections were relatively small this year, so I decided to include all 30 students in my analysis throughout this year. Most of my students are part of the first elementary class at North Star Academy. This means that they have attended North Star Academy for their entire K12 experience. 17 of 30 students identify as African American, five as African, and seven as Latino/Latina.

The AP Calculus BC curriculum is aligned to that of a Calculus I and Calculus II course during the Freshman Year at a University. I have taught this course for the past five years and have had the challenge of creating and iterating on the curriculum over these years. In May, students have the opportunity to take a AP exam to earn college credit. At most institutions, if a student earns a four or five on the AP exam, they can receive credit for both courses. Success in the course is dependent on strong foundations in algebra.

Another unique aspect of this group is that 10 of 30 students took a Pre-AP Calculus course the previous year and 20 of 30 took AP Calculus AB the previous year. For the Pre-AP Calculus students, they have already covered Limits and Derivatives in their previous class. For the AP Calculus AB students, they have already covered Limits, Derivative, and Integrals. For the Pre-AP Calculus students, the first two quarters of materials will be completely new content. For the AP Calculus AB students, the first two quarters will be review of prior knowledge. My students are actively engaged in multiple extra curriculars and jobs while balancing a rigorous course load. Nathan, Paul, Nakeba, and Sade are heavily involved with the North Star Volleyball Program. Deja, Kayla, and Naím work in retail stores while Noah is an intern at Audible in Newark. Wilschnaida started the year with us but had to transfer to a school in Connecticut in February.

# Academic Data Analysis for All Students

## Students’ learning, relative to the Proficient and Ambitious Goal:

Throughout the 2019-2020 school year, I focused my curriculum and instruction on the AP Calculus Curriculum guide. This guide outlines a list of 38 standards across the major ideas of limits, derivatives, integrals, and series. These standards are assessed quarterly during interim assessments and within quarters through unit tests. Due to the COVID-19 pandemic, the number of standards was limited to only 29 of the original 38 standards. These 29 standards covered over 90% of the content within limits, derivatives, and integrals but fails to include any standards on series.

At the beginning of the school year, I set the following goals for my students’ academic performance:

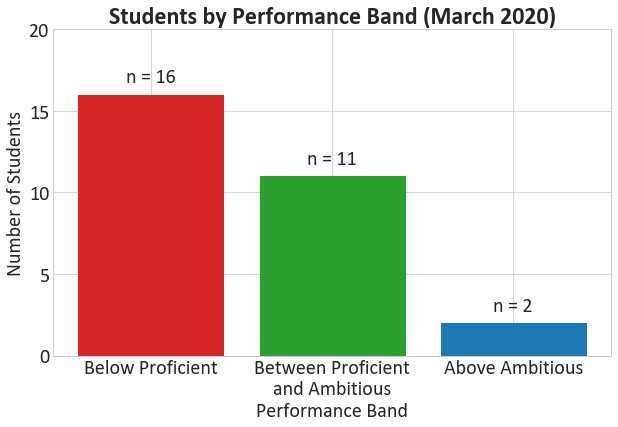
**Proficient Goal:** On average, students will achieve an average standards mastery of 55% of the selected set of standards.

**Ambitious Goal:** On average, students will achieve an average standards mastery of 65% of the selected set of standards.

These two goals are aligned to the AP scores that have been given for previous AP Calculus BC exams. Historically, a score of 55% yields a 4 on the exam and a score of 65% yields a 5 on the exam. As mentioned previously, a score of a 4 or 5 can earn students college credit for Calculus I and Calculus II at most higher education institutions. Given these criteria, for college credit, these scores can be used as a proxy for measuring college readiness for college STEM courses.

## All student’s academic achievement, displayed relative to the Proficient and Ambitious Goal:

Throughout the school year, student mastery was recorded for each the 29 standards. For each student, the percent mastery for each standard was calculated based on the number of items administered. These *standard averages* were then averaged to calculate an overall standards mastery for each student. The visualization above shows the number of students performing below proficient, between proficient and ambitious, and above ambitious.

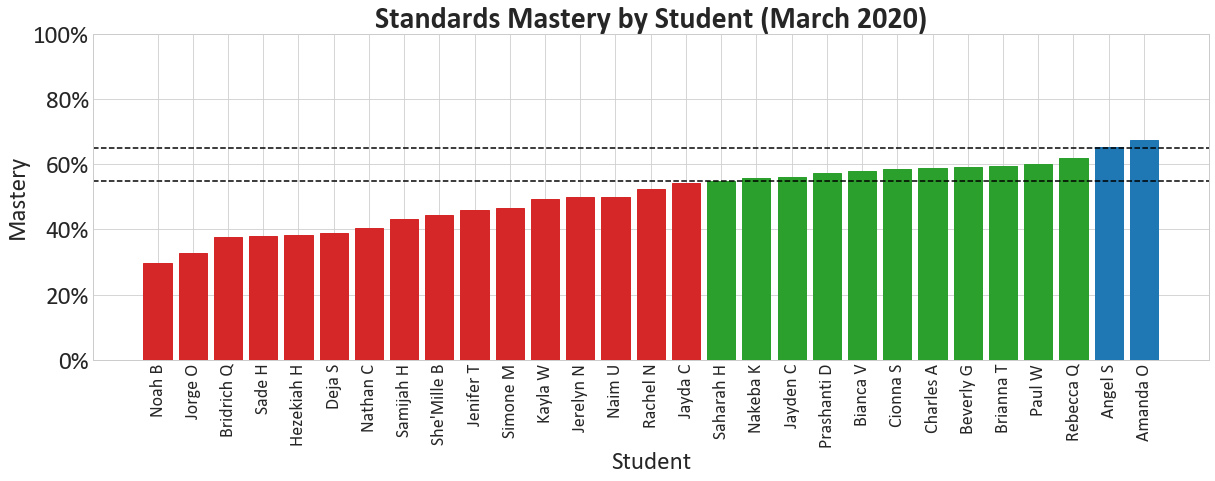


There are two students who attained a mastery above the ambitious goal of 65% mastery. 11 students surpassed the proficient goal but did not reach the ambitious goal. 16 students had not yet reached the proficient goal. Overall, this shows that approximately 45% of students achieved the Proficient Goal.

In the context of the AP exam, it is important to note that a score of a 3 is considered passing the exam. Historically, if a student achieves a percent score of 40% on the AP exam, this is sufficient for scoring a 3. From this perspective, 23 students are on track to score a 3 or higher on the AP exam in May. I believe it is important as a teacher to push for the 4 or 5 to maintain high expectations, but this in an interesting implication for students. Some colleges and universities will grant college credit for scores of a 3.

## Distribution of academic performance for all students:

The figure below shows the overall standards mastery for each student.



The upper dotted line represents the ambitious goal and the lower dotted line represents the proficient goal. We can see that Angel and Amanda had the highest overall standards mastery for the course. The range of scores for students that met the proficient goal is 12% between Saharah and Amanda. The range of scores for students that met the ambitious goal is 25 between Noah and Jayda. These observations show that there was a smaller spread of scores for students above the proficient goal than below the proficient goal.

## My perspective on these whole-class results:

The data above shows a wide range standards mastery for students. The highest mastery 67% while the lowest was 29% for a range of 38%. This accurately reflects the wide range of skill levels in mathematics that I expected at the start of the year. Some students have previously learned all the content assessed while others had only learned a fraction of it in their prior course.

I am very impressed by Angel and Amanda’s scores at the top of the class. Angel loves math and is always eager to get started and complete his homework right away. Amanda is a deep thinker and has deep conceptual knowledge of calculus. I am also impressed by Jayden who was already meeting the proficient goal at this point in the year. She was enrolled in Pre-AP Calculus last year, so she learned all the content this year for the first time.

I would have liked to see a higher number of students above the proficient goal at this point. I think student’s previous math course was a major determining factor (see research questions) when looking at the names that are listed as below proficient. In working with students, I think there are two factors leading to these below proficient scores: a) test anxiety/sophistication and b) need for scaffolding in mathematics. Hezekiah and Sade are always participating and understand the material in class but have difficulty synthesizing and applying their knowledge and skills during an exam. Noah and Deja have struggled with the calculus content throughout the year and would benefit from smaller group and one-on-one tutoring. Overall, it is my responsibility to own these results and intentionally chart a path forward to try to get all students to a proficient level.

# Academic Data Analysis for Subgroups of Students

## Research Question #1:

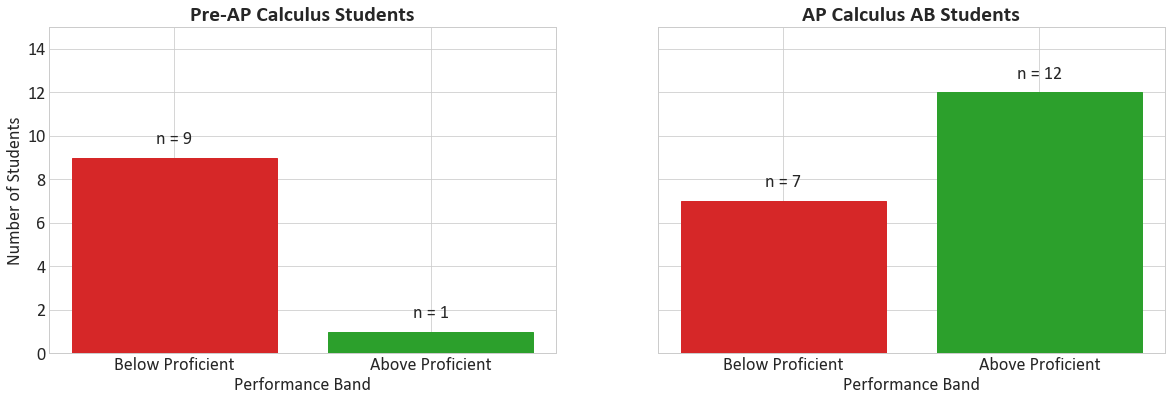
What, if any were the achievement differences between students who took Pre-AP Calculus and those who took AP Calculus AB during their junior year?

## Rational for selection of research question #1:

This year’s cohort was unique in comparison to previous years. Historically, my students have all been enrolled in Pre-AP Calculus the previous year and then start AP Calculus BC with me. This year, about 33% of my students were coming from Pre-AP Calculus and 67% were coming from AP Calculus AB. The course is designed to continue where students finish in Pre-AP Calculus. The implication for AP Calculus AB students is that the first two quarters of material is teaching of prior content. I intentionally redesigned the lessons for this year so that they did not match exactly to what this group learned the previous year.

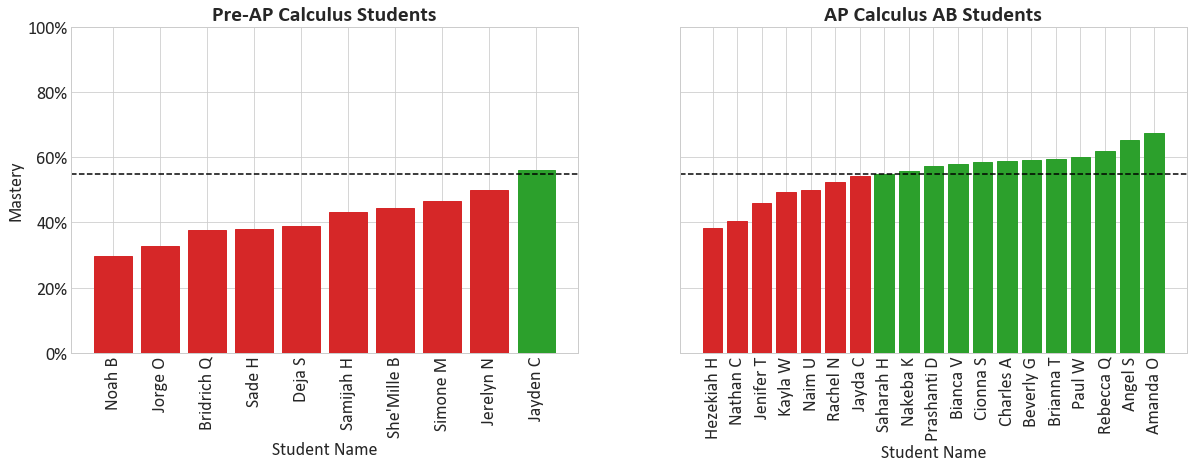
## Analysis of research question #1:

The figure below shows the number of students who performed below and above proficient separated by previous course.



The left graph reveals that 9 students from the Pre-AP Calculus cohort did not achieve the proficient goal and only 1 student met this goal. The right graph reveals that 7 students did not reach the proficient goal and 12 students did meet this goal. From the visual here, there appears to be a significant difference between the two subgroups of students. A T-test for the means of these two independent groups of students calculated a p-value of approximately 0.00013 which is well below the commonly accepted threshold of 0.05. This confirms a statistically significant difference between these two students.

The graph above shows the overall standards mastery for each student separated by previous class.



We can see from the graph above that Jayden one the single student from the Pre-AP Calculus cohort who achieved at the proficient goal. The range of mastery scores for the Pre-AP Calculus cohort is approximately 24 percentage points. The range of mastery scores for the AP Calculus AB cohort is approximately 29 percentage points. Through this analysis we can see that there is a significant difference between students who were enrolled in Pre-AP Calculus in comparison to students who were enrolled in AP Calculus AB. The AP Calculus AB cohort achieve statistically significantly higher on the assessed AP Calculus BC standards. This confirms my intuitions that this group would achieve at higher levels since the content they are assessed on was predominantly review.

When teaching future groups of students, it is crucial that instructors do not overlook these different cohorts. Extra care and intention should be taken to ensure that differentiation occurs to support the Pre-AP Calculus cohort in achieving the proficient goal and for the AP Calculus AB cohort to push towards the Ambitious Goal. School leaders and teachers may consider two different approaches. The first option is to place each cohort in their own AP Calculus BC section. This would allow the teacher to calibrate instruction for a more homogenous group of students. The second option is to continue to place students in a heterogenous group of classes, similar to the sections covered in this study. In this second case, the teacher should look for opportunities to leverage the AP Calculus AB cohort to support the Pre-AP Calculus cohort through intentional pairing in seating charts and reciprocal teaching strategies.

## Research Question #2:

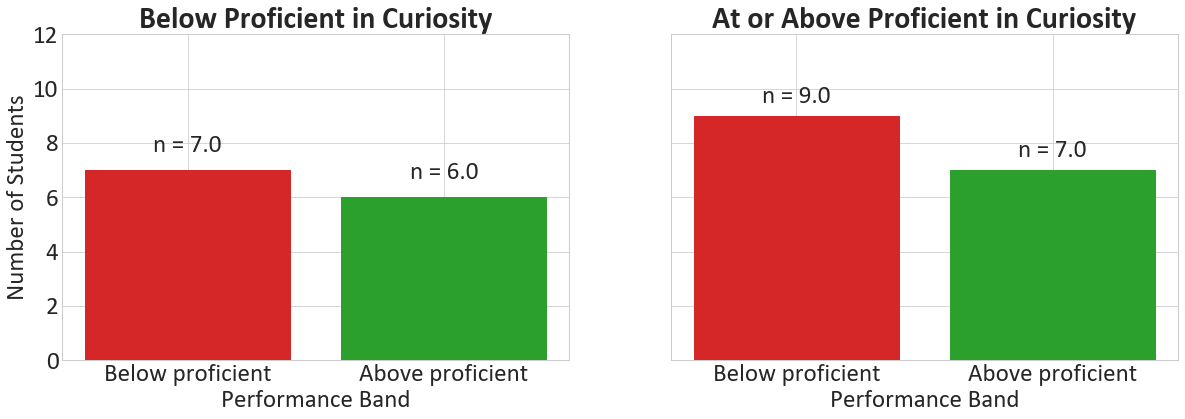
What, if any, achievement differences exist between students that scored at or above mastery in character development vs. students that scored below mastery?

## Rational for selection of research question #2:

We focus a ton on academic data in school because it is a tangible metric for measuring student outcomes on the way to college. I enjoyed developing character strengths this year. Through this second year at RELAY, I have gathered data across 8 indicators for the character traits of Curiosity, Grit, and Gratitude. I will be examining the relationship between students’ final character scores and final academic mastery scores.

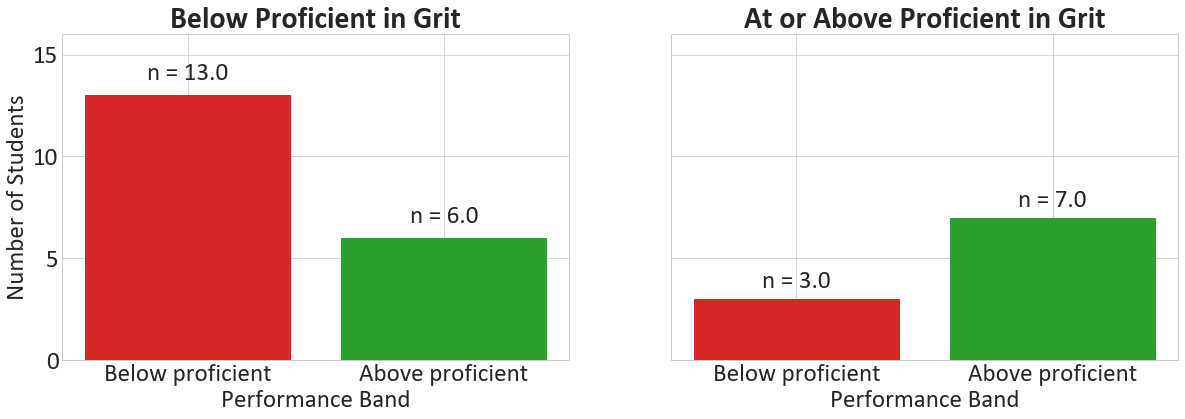
## Analysis for research question #2:

The following three figures show the number of students who scored below or above proficient on the AP Calculus BC standards. The graph below the left shows the counts for students below proficient in curiosity (less than 4) and the graph on the right shows the counts for students at or above proficient in curiosity (greater than or equal to 4).



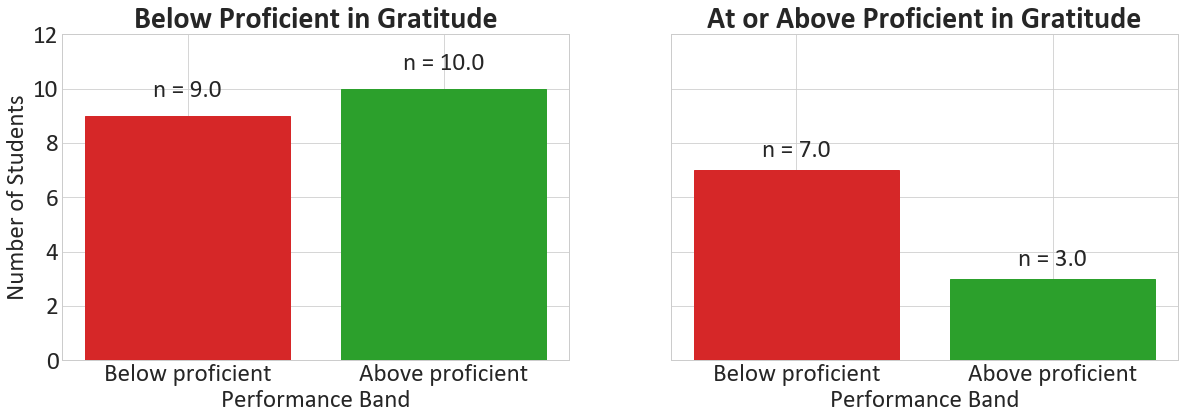
In both subgroups of students, more students achieved below the proficient goal than did above the proficient goal. 46% of students who were below proficient in curiosity achieved above the proficient goal. 43% of students who were at or above proficient in curiosity achieved above the proficient goal. These proportions are very close to each other. A T-test for two independent samples revealed a p-value of approximately 0.960644. There appears to be no significant difference between these subgroups.

The graph below the left shows the counts for students below proficient in grit (less than 4) and the graph on the right shows the counts for students at or above proficient in grit (greater than or equal to 4).



The subgroups broken down by grit proficiency reveal interesting differences. 32% of students who were below proficient in grit achieved above the proficient goal. 70% of students who were at or above proficient in grit achieved above the proficient goal. These proportions are starkly different from each other. A T-test for two independent samples revealed a p-value of approximately 0.05177. The commonly accepted threshold for significance is 0.05. In this case, we cannot conclude that there is a statistically significant difference in student’s achievement based on grit. However, further investigations on the difference seen here with a larger set of students may reveal stronger significance in the future.

The graph below the left shows the counts for students below proficient in gratitude (less than 4) and the graph on the right shows the counts for students at or above proficient in gratitude (greater than or equal to 4).



Students who were not proficient in gratitude appears to achieve at slightly higher rates than those who are at or above proficient in gratitude. 53% of students who were below proficient in gratitude achieved above the proficient goal. 30% of students who were at or above proficient in gratitude achieved above the proficient goal. This analysis implies that gratitude as a negative effect on achievement on AP Calculus BC standards. A T-test for two independent samples calculated a p-value of 0.41587. This reveals that there is not a statistically significant difference between these two subgroups of students.

Through this analysis, the data does not show a consistent connection between proficiency in curiosity and gratitude and students’ achievement on AP Calculus standards. There was not enough evidence to suggest a statistically significant relationship between grit and student achievement. However, the large difference between 70% and 32% as described above warrants further investigation.

For future courses, teachers should continue to investigate curiosity and gratitude as important character traits in a students’ development as a future world citizen. There is some evidence that grit is a strong factor in developing academic mastery in AP Calculus. This aligns with the findings of Angela Duckworth in her research on Grit. A more robust analysis may be done in the future using Duckworth’s Grit inventory. There may be some confounding variables that are not accounted for in this analysis including homework completion or attendance. In future renditions of the course (or any math course), teachers may choose to focus on primarily developing grit to improve student achievement based on these findings.

# Academic Data Analysis for One Student

## Student Description:

* Describe the student (context, information, etc.)

## Student’s academic achievement throughout the year:

* Visualization of mastery over time relative to the rest of the class

## Connection to additional data source:

* Get some other information on this student that can be connected here. (books read, character data, some other metric like homework, etc.)

# Character Data Analysis

## Character measure:

During my second-year teaching in New Orleans (2014 – 2015), I audited the RELAY course, *Teaching Character and Creating Positive Classrooms.* I learned about these same eight-character strengths discussed in my second year at RELAY. At that time, I chose to focus on curiosity, grit, and gratitude for the following reasons:

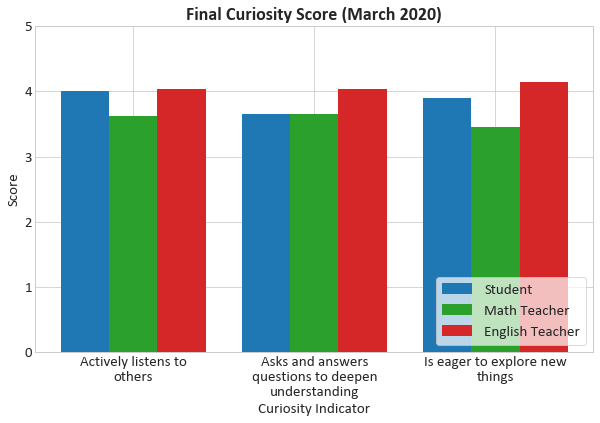
* Curiosity – When one is curious about a subject, they are naturally more inclined to learn more and develop their skills in that subject. Curiosity is a muscle that can be developed for any subject and AP Calculus is a great content to work on developing this aspect of character because it can be initially uninteresting.
* Grit – College is tough! I want my students to develop their grit so they can succeed in future college STEM courses where they will have trouble. We have seen alumni switch out of STEM majors due to difficulty in the past. I want to disrupt this narrative with my students this year.
* Gratitude – Any strong community is based on appreciation for those around you. I want to give my students opportunities to develop this character strength so be thankful for others in the good and the bad times.

In my second year at RELAY, I wanted to tap back into these character strengths with my group of 29 seniors. At the beginning of the 2019-2020 school year, I thought that it would be important for my students to be involved in the character trait that we tracked for the school year. For my 12th grade students, I have found that involving students in instructional decisions improves investment. We started the year with a lesson designed to introduce curiosity, grit, and gratitude and then narrow down to one trait. Through a discussion, both classes decided to keep all three traits! In the words of Charles, “All of these traits are important so I think we should work on all of them this year.”

We decided to track all these character strengths throughout the year and I tried to promote each of these in *micro moments* throughout the course. The results for all three traits are captured in Appendix 1. As an instructor, I decided to focus specifically on developing curiosity. The analysis and discussion below are focused on curiosity.

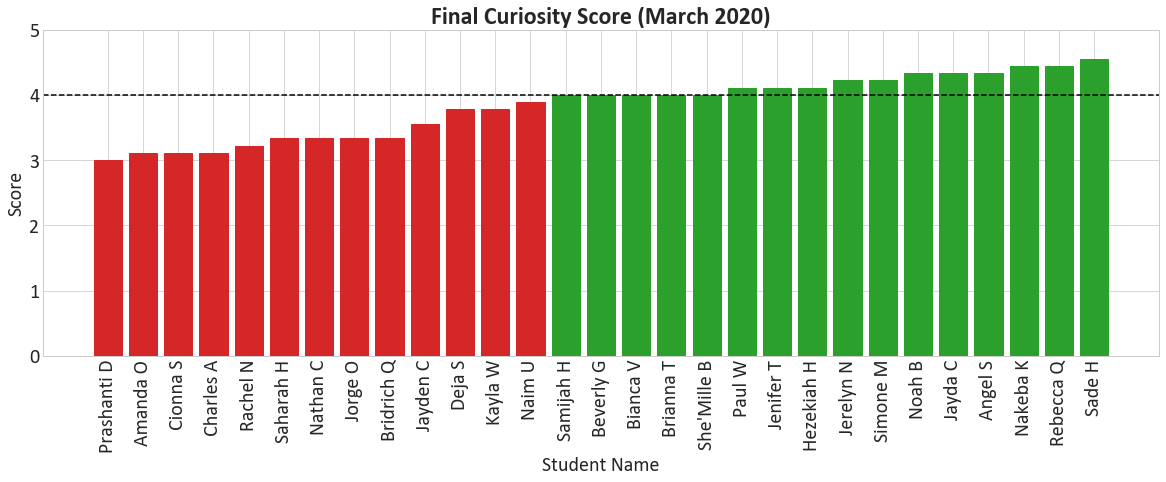
## Character results analysis:

The figure below shows the average score of each curiosity indicator aggregated by the evaluator.



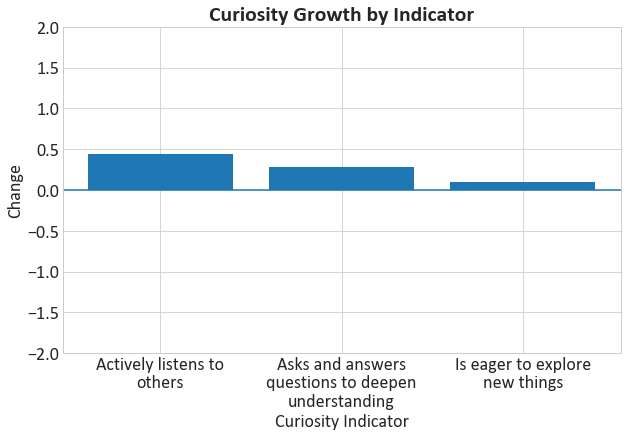
The students’ scores were students’ self-assessment of themselves on that indicator. The math teacher scores represent scores given by me and the English teacher scores given by each student’s respective English teacher. For all three indicators, the English teacher average is the highest for the class. This may imply that this group of students’ curiosities is stronger in English and/or Humanities classes than Math and/or STEM classes.

The figure below represents that final curiosity score by students where each students score is average across the three indicators and the three evaluators (Student, Math teacher, and English teacher).

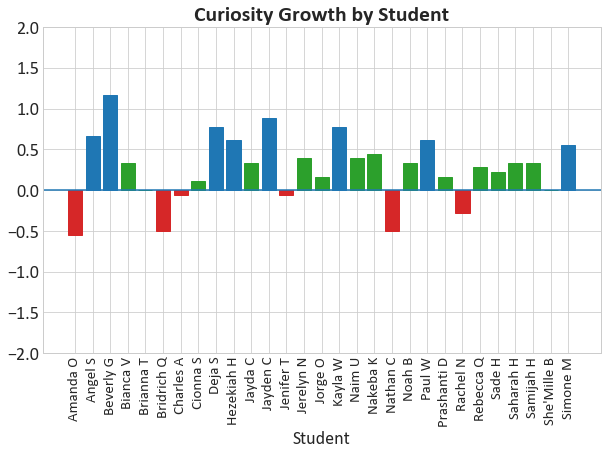


From the graph above, 16 of 29 (55%) students were at a score of 4 or higher for curiosity. There appears to be a subgroup of students who are at or below 3.5 for curiosity. When I step back and think about the course, I remember Sade, Jayda, and Angel asking questions throughout the course and this matches up with their high curiosity scores. When I think about the students towards the left end of the graph, they tend to be more reserved in class and do not ask as many questions.

The figure below shows the average growth for each curiosity indicator between quarter 1 and quarter 3.



There was an increase in all three indicators from the start of the year, though at varying magnitudes. We can see the largest growth for the class occurred for the indicator *actively listens to others* and there was minimal average growth for *is eager to explore new things.* The figure below shows the average growth for curiosity aggregated by student.



From this visual we can see individual trends by students. Beverly, Jayden, Kayla, and Deja showed the greatest increase in curiosity over the course of the year. Amanda, Bridrich, and Nathan all showed a decrease in their curiosity scores throughout the year.

## Character results storyline:

During this school year, I built my students curiosity through a roll-out lesson of the curiosity, modeling curiosity as a teacher, and providing authentic opportunities to develop student curiosity through mathematical tasks. In the roll-out lesson, we discussed what curiosity looks like in an academic and social context. I modeled how curiosity might look in a college setting when meeting someone for the first time to make a connection. I then provided students an opportunity to practice this with their partner at their seats. This was particularly relevant to my 12th grade students because they will be attending college soon. They will be meeting students from all over the country and may face challenges if they choose to attend a predominantly white institution.

After this character lesson, I implemented Think Aloud’s throughout my introduction to new material for future math lessons. Rather than naming steps and following a procedure, I would script a series of questions that would demonstrate my thinking for breaking down the questions and informing each of the steps that followed. Following the think aloud, rather than Checking for Understanding on my steps, I asked students to name the key *thinking* questions that informed my thinking. The figure below provides an example of a script for breaking down an AP Multiple Choice question. This modeling was effective in developing students’ curiosity by asking their own questions and navigating tasks.

**Example #1:** Let be the function given by . On which of the following intervals is the function increasing?

1. and
2. only
3. only

**Scripted Questions:**

* What am looking for?
* What do I have to work with?
* How can I get from to find out where it is increasing?
  + I know that is increasing if is positive.
* I have a function algebraically, how can I see when the derivative is positive?
  + I can use a sign chart.
* But wait, what do I use make the sign chart for?
  + I want the sign of the derivative so make it for the derivative.
* How do I start this?
  + I can find the zeros of the derivative.
* Now how do I find the signs between the zeros?
  + I know that 0 is in the middle here, so can substitute this.
* So which answer matches the best with my work – does this match?
  + Yes, I think so
  + No, this is where the function is decreasing.
  + No.
  + No.
  + No.

During this school year, I intentionally decided to provide time for students to ask questions throughout chunks of the lesson. This has been discouraged at my school in favor of promoting more practice. I realized that suppressing these opportunities to question the content, were limiting students’ growth in curiosity. During these moments of questioning, I would highlight great questions that students would ask that either a) clarified their own understanding or b) asked a *what if* question that pushed the rigor of the content further.

In addition to creating spaces for students to ask questions, my school focused on building student discourse in our classes. This manifested in my classroom as student led discussions for reviewing tasks after a round of independent work. A student would stand at the podium and be the scribe for the class’ review of the task. During this time, students were pushed to listen carefully to their peer’s arguments and respond with questions to dive deeper into their peers’ thinking. These are moments for students to directly practice skills associated with two curiosity indicators: ‘Actively listens to others’ and ‘Asks and answers questions to deepen understanding’.

In MATH 304, I learned about a key instructional technique called *Three Act Tasks.* In most math classes, students are given a question with all the relevant information needed and asked to solve it. A three act task challenges students to consider a situation and then ask their own questions about what they see. These questions are then leveraged to launch an investigation into a question authentically generated by students during the lesson. This is a game changer for student curiosity. This pushes students to see the world mathematically and ask questions about what they see.

The indicator ‘Actively listens to others’ showed the largest increase for my students. I attribute this primarily to the prioritization of discourse throughout my school building. Students were developing this aspect of curiosity in every single one of their classes. This is supported by the average score for this indicator being slightly above 4 when English teachers were asked to score their students in the final round of data collection.

I rated my students on average below proficient (4) for the indicator ‘Is eager to explore new things.’ English teachers on the other hand rated this above proficient. Many of my students were enrolled in African American Literature this year. I know from speaking to students and teaching that students really enjoy this course and the discussions since they are highly relevant to everyday lives. This element of the English courses likely empowered students to reveal their *eagerness to explore new things* in this English.

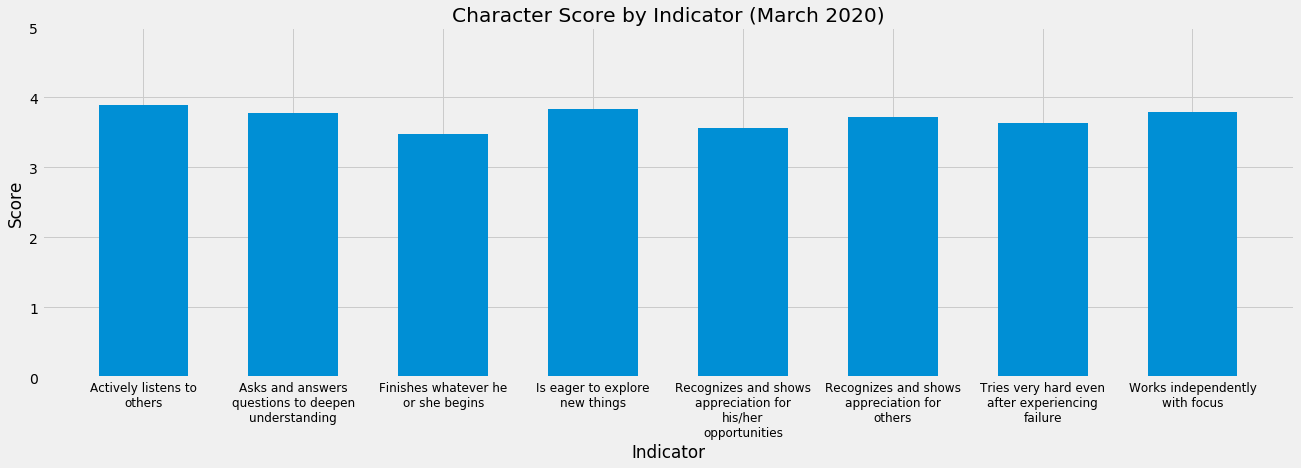
In the future, I will need to be more intentionally in creating experiences for my 13 students below proficient to develop their own curiosity. I think that publicly logging exemplary questions would be impactful in providing exemplars for these students to craft their own questions. In terms of my curriculum, I need to find more engaging questions/tasks that are relevant to my students so that they can develop and demonstrate their eagerness to explore new things. I intend to observe classes of African American Literature so that I can see this eagerness in action. There may be opportunities for our work to overlap between classes, which would drive up curiosity and engagement even more between our classes.

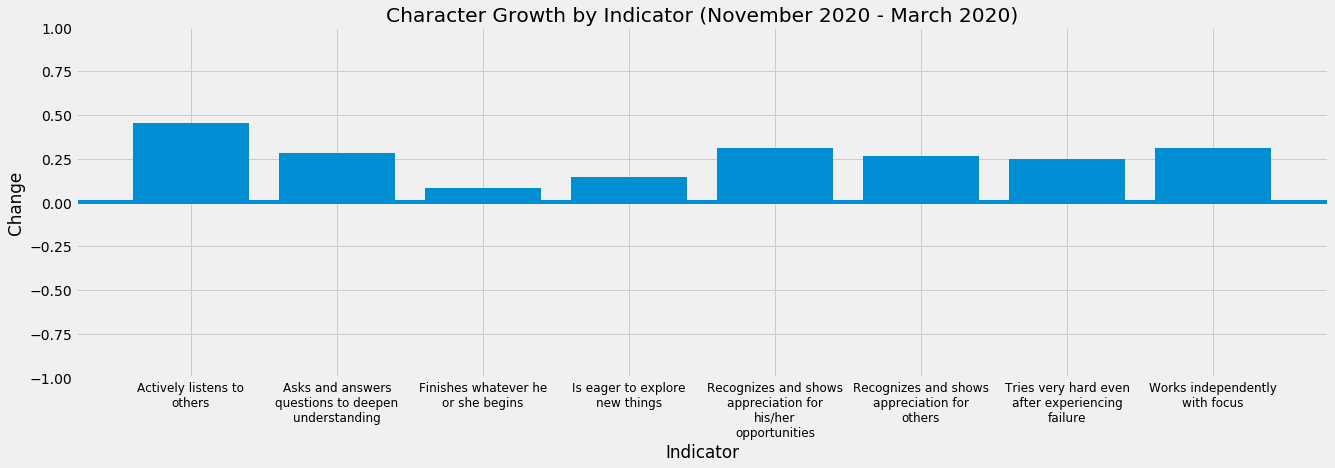
# Next Steps from Analyses of Academic and Character Data

## Action Step #1 (from academic analysis):

## Action Step #2 (from character analysis):

# Appendix 1: Character Data for Curiosity, Grit, and Gratitude





# Appendix 2: Correlation Analysis for Character Strength Indicators and Mastery

## Rational for selection of research question #2:

We focus a ton on academic data in school because it is a tangible metric for measuring student outcomes on the way to college. I enjoyed developing character strengths this year. Through this second year at RELAY, I have gathered data across 8 indicators for the character traits of Curiosity, Grit, and Gratitude. I am curious to see if there are any links between individual indicators and standards mastery for my group of 29 students. I will be examining students’ scores for themselves as a proxy for measuring students self-perception and how it is related to academic performance.

## Analysis of research question #2:

The figure below shows eight scatter plots for the final self-assessment score for each character strength indicator vs. overall standards mastery.



The graphs above show a clustering of self-assessed scores for each indicator that tend to be in the range of 3 (XXX) to 5 (XXX). For 7 of 8 indicators, there is a negative association between the indicator score and overall standards mastery. The single indicator that was showed a positive association was ‘Works Independently with focus’.

The table below shows the slope, intercept, and correlation coefficient for each character strength indicator in relation to overall standards mastery.

|  |  |  |  |
| --- | --- | --- | --- |
| indicator | slope | intercept | r^2 |
| Is eager to explore new things | -0.029655 | 0.620587 | 0.052376 |
| Asks and answers questions to deepen understanding | -0.033073 | 0.625920 | 0.103636 |
| Actively listens to others | -0.025687 | 0.607781 | 0.037672 |
| Finishes whatever he or she begins | -0.000193 | 0.505732 | 0.000003 |
| Tries very hard even after experiencing failure | -0.029129 | 0.617531 | 0.064941 |
| Works independently with focus | 0.033331 | 0.376308 | 0.085028 |
| Recognizes and shows appreciation for others | -0.011491 | 0.550602 | 0.008937 |
| Recognizes and shows appreciation for his/her opportunities | -0.024846 | 0.602702 | 0.039347 |

The correlation coefficients () are very low for all indicators. This shows that there is not a strong association between each indicator and overall mastery. The smallest correlation coefficient was found for ‘Finishes whatever he or she begins’ and the greatest correlation coefficient was found for ‘Asks and answers questions to deepen understanding.’