Math Modeling

THE EPSILON SCHOOL

Modeling School Expansion

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BACKGROUND

Context about the Epsilon School

Challenge Summary

Background Information:

Current Population: 490 students

Planned increase: 140 students

Predicted Students: 630 total students

7 new faculty available

Central Question:

How can we best split the 7 staff hires to ensure that all of our subjects have the staff they need for the upcoming year?

Assumptions

Students can enroll in multiple departments.

Incoming sophomore class is **140** students larger than graduating class.

5% dropout rate before graduation which happens entirely in senior year.

Percentage of students taking a class remains the same

All courses are year-long.

Sophomore, junior, and senior course demand is **proportional** to enrollment.

The current year's ratio is the ideal student-teacher ratio, but the model works towards slightly more parity by balancing and controlling staff increases.

Teachers teach 6 classes

Constraints

- Teachers are only able to teach **one class at a time**.
- Foreign language teachers may teach at most 2 languages.
- Students must take exactly 6 classes.
- Incoming sophomore class is **140** students larger than graduating class.

GOAL!

Even after addition of 140 more students to the school, preserve original Student : Teacher ratio as best as possible while also taking into account reasonable adjustments.

Project Methodology

Find initial ratio

Calculate initial subject teacher: student ratios

Find outliers

Model the Scenario and see which departments have outlying Student:Teacher ratios

Allocate teachers

Find optimal teacher allocations

Find final ratio

Ensure final ratios are as even as possible

Necessary Variables

Initial ratios

Initial departmental teacher:student ratio

Current students

Current student enrollment (490)

Predicted students

Predicted students for next year (630)

Dropout rate

School dropout rate is set at 5%

Current teachers

Current staff hires (31)

Predicted teachers

Predicted teachers for next year (38)

Necessary Variables Cont.

Total Predicted Course Enrollment	New Teacher: Student Ratio	% Increase in Students Per Teacher
To use when predicting the distribution of students in the future (as the grades move up)	To compare with old and see which department has unreasonable ratio	Easier to visualize the increase caused by grade change and map to number of teachers added

02

ANALYZING DATA

Cleaning & processing data

GIVENS

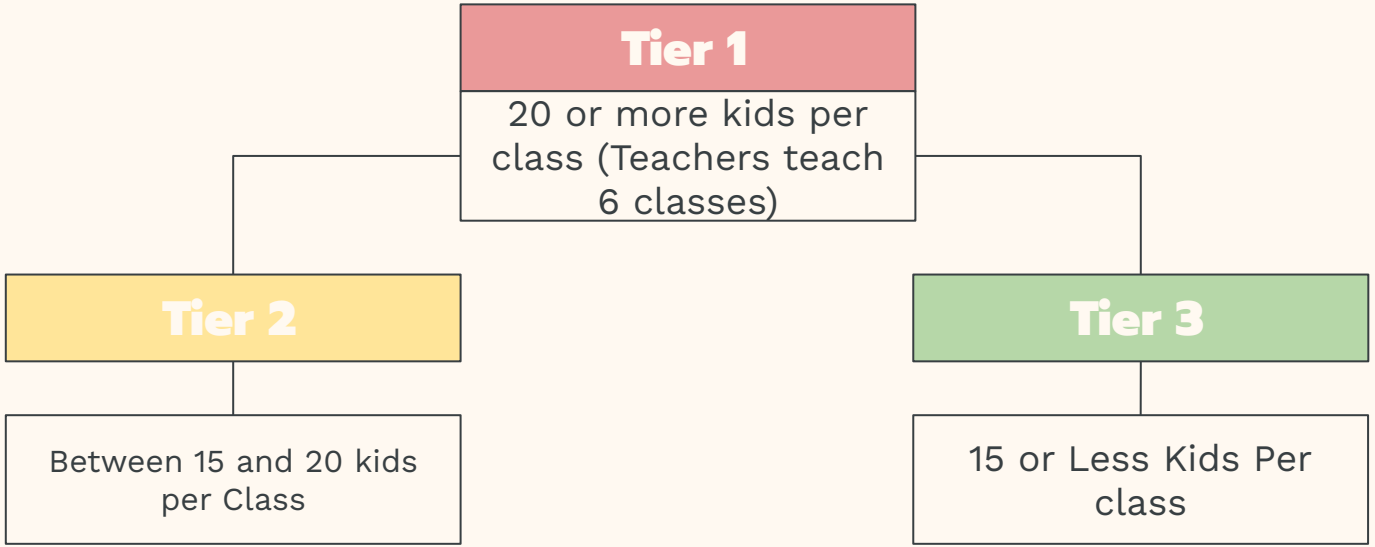
OF STUDENTS IN EACH DEPARTMENT (BY GRADE)

OF TEACHERS IN EACH DEPARTMENT

Current & Predicted Total Course Enrollments

Department	Students (10th)	Students (11th)	Students (12th)	Dept. Total
Mathematics	184	201	262	647
Biology	198	95	26	319
Chemistry	59	126	109	294
Physics	50	58	183	291
English	183	155	152	490
Social Studies	183	131	59	373
Spanish	51	26	33	110
French	41	32	49	122
German	19	22	10	51
Art	31	33	35	99
Music	50	56	49	155
Total Course Registrations	1049	935	967	2951
Predicted Total Students (Divide By 6)	175	156	161	492

STUDENT TEACHER RATIO RANK



Current Teacher : Student Ratios

Department	# of Students	# of Teachers	Student:Teacher Ratio
Math	647	6	108:1
Biology	319	4	80:1
Chemistry	294	3	98:1
Physics	291	3	97:1
English	490	5	98:1
Social Studies	373	5	75:1
Spanish French German	110 122 51	3 (2 For Each Subject)	55:1 61:1 26:1
Art	99	1	99:1
Music	155	1	155:1

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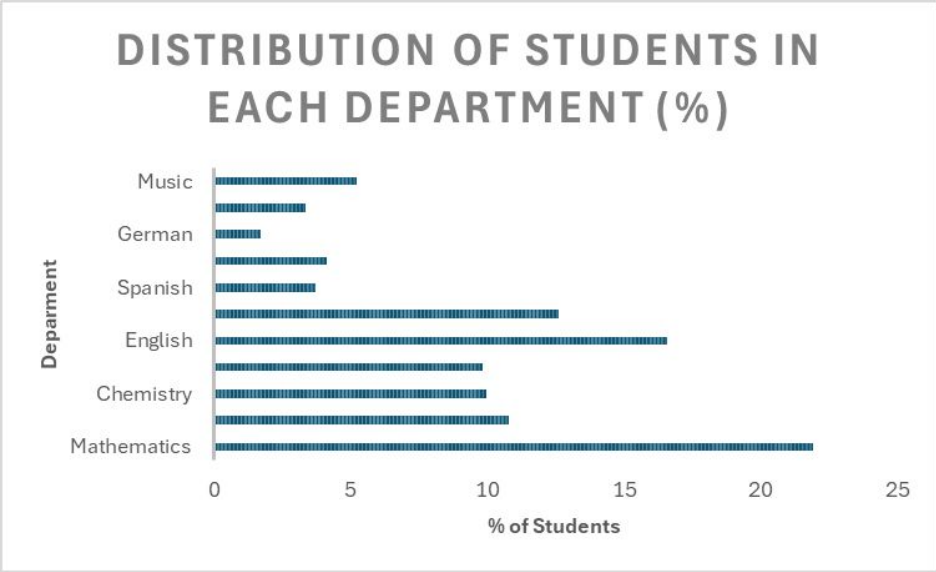
VISUALIZING DATA

Creating graphs & figures

DEPARTMENT COMPOSITION

Analysis

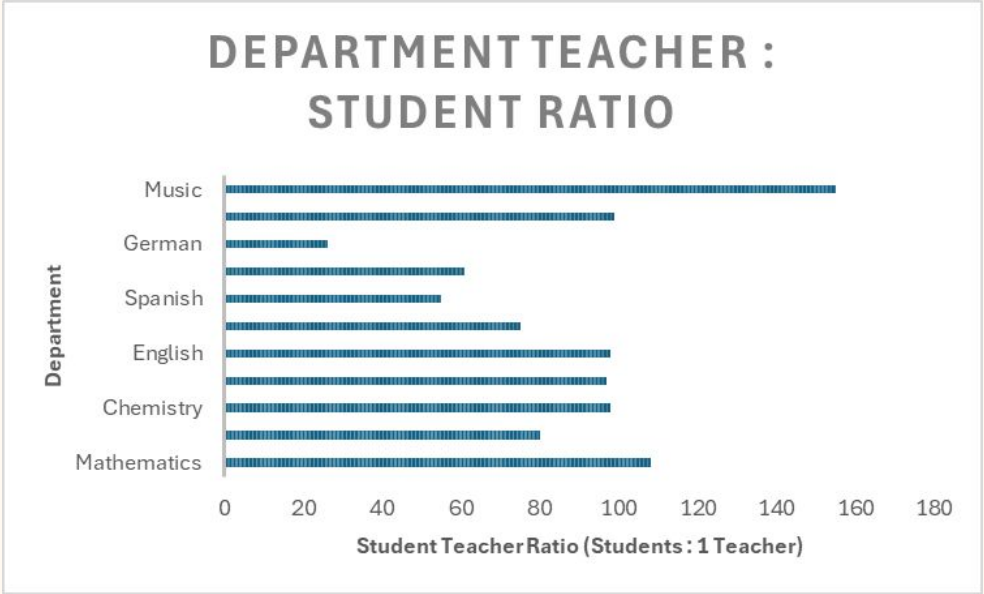
This graph shows the distribution of students in each department (student enrollment / total students).



STUDENT:TEACHER RATIOS

Analysis

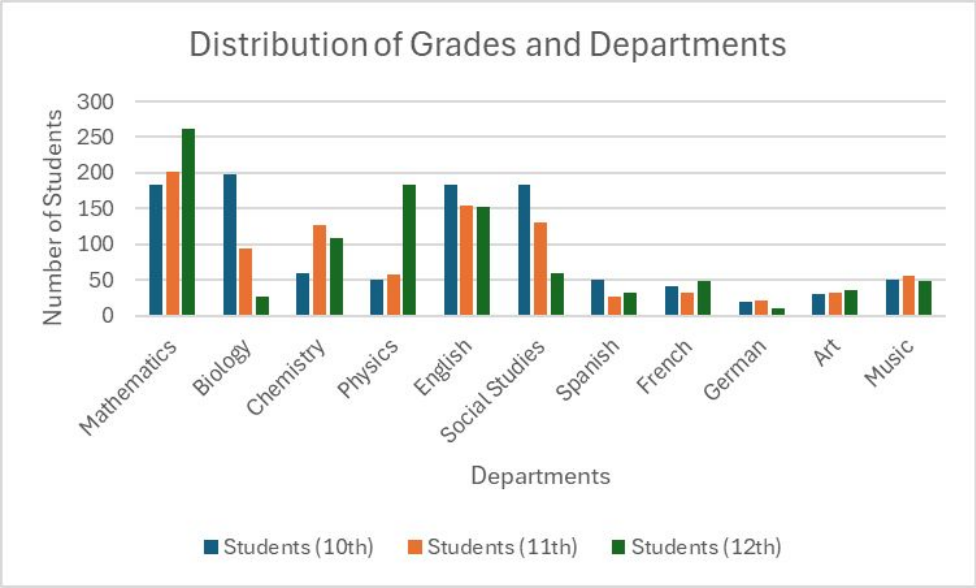
This graph shows the distribution of student:teacher ratios and will be useful going forwards.



GRADES AND DEPARTMENTS

Analysis

This graph shows the distribution of each department and the grade levels that compose them. Once the sophomores are added, we will see a big change.



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PROCESS

Our Methodology

PART 1: PREDICTING # OF STUDENTS

01 DISPLAY	02 MATH	03 PREDICT
Display all of the Students and in the Table	Add them all up to find the department totals. Divide by 6 to find number of students (approx.) because we assumed 6 classes each	Predict next years' totals by adding 140 and moving each class up. KEEP IN MIND 5% SENIOR DROP OUT! Ex: 161 * 1.05 + 140 = 309 Sophomores. We got 492 total students before expansion, 632 students after, which is close.

Current & Predicted Total Course Enrollments

	Students (10th)	Students (11th)	Students (12th)	Dept. Total
Total Course Registrations	1049	935	967	2951
Predicted Total Students	175	156	161	492
Predicted Next Year	309	175	148	632

PART 2: PREDICTING DEPARTMENT TOTALS OF 10TH GRADE

01 BASELINE	02 APPLY	03 PREDICT
Find the percent of department registrations out of the total registrations for 10th grade. Use last year's data. Ex: Math is 184/1049	Multiply this old ratio with the (309*6) new Students. Ex: Math is (1854 * 184/1049) = 325	Sum all of the departments to get a correct 1854 course enrollments.

PART 2: PREDICTING DEPARTMENT TOTALS OF 11TH GRADE

01 BASELINE	02 APPLY	03 PREDICT
Find the percent of department registrations out of the total registrations for grade. Use last year's data. Ex: Math for 11th graders is 201/935	Multiply this old ratio with the new Students (1049 Sophomores Last Year). Ex: Math is (1049 * 201/935) = 226	Sum all of the departments to get a correct 1049 course enrollments.

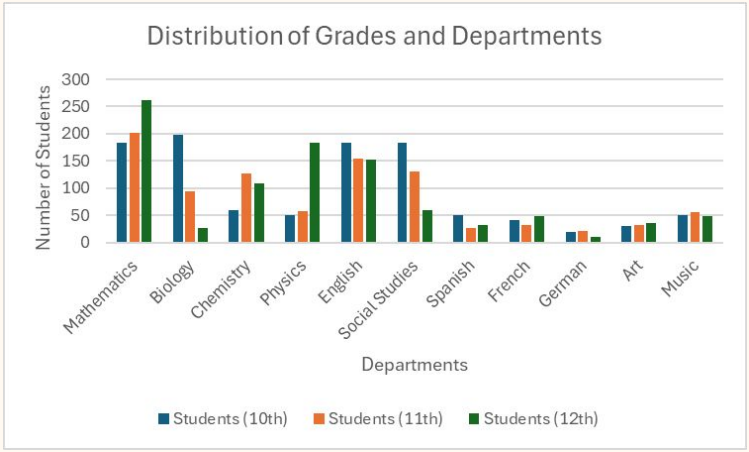
PART 2: PREDICTING DEPARTMENT TOTALS OF 12TH GRADE

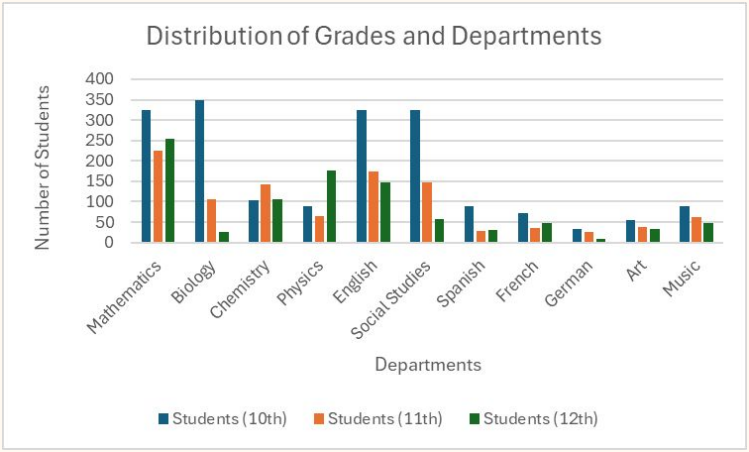
01 BASELINE	02 APPLY	03 PREDICT
Find the percent of department registrations out of the total registrations for grade. Use last year's data. Ex: Math for 12th graders is 262/967	Multiply this old ratio with the new Students (935 Juniors Last Year). Ex: Math is (935 * 262/967) = 226	Sum all of the departments to get a correct 935 course enrollments. This makes sense because 95% of this is 888, and 6 times the graduating seniors (148) is 888

Predicted Course Enrollment (Next Year)

Department	Students (10th)	Students (11th)	Students (12th)	Dept. Total
Mathematics	325	226	253	804
Biology	350	107	25	482
Chemistry	104	141	105	351
Physics	88	65	177	330
English	323	174	147	644
Social Studies	323	147	57	527
Spanish	90	29	32	151
French	72	36	47	156
German	34	25	10	68
Art	55	37	34	126
Music	88	63	47	199
Total	1854	1049	935	3838

GRADES AND DEPARTMENTS





New Predicted Student : Teacher Ratios

Department	# of Students	# of Teachers	Student:Teacher Ratio
Math	804	6	134:1
Biology	482	4	120:1
Chemistry	351	3	117:1
Physics	330	3	110:1
English	644	5	128:1
Social Studies	527	5	105:1
Spanish French German	151 156 68	3 (2 For Each Subject)	76:1 78:1 34.1
Art	126	1	126:1
Music	199	1	199:1

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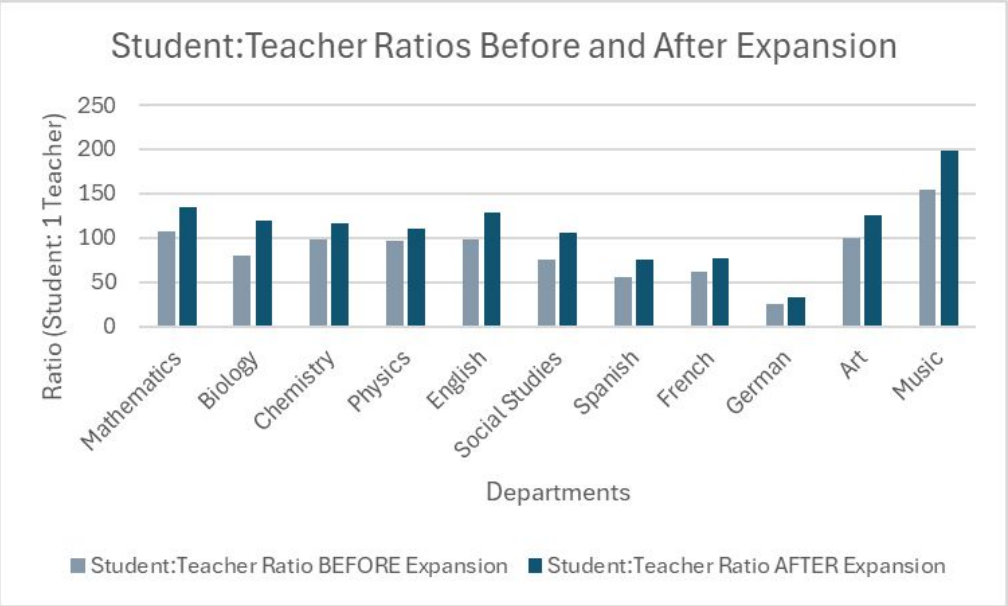
SOLUTION

Answering the Question

STUDENT:TEACHER RATIOS

Analysis

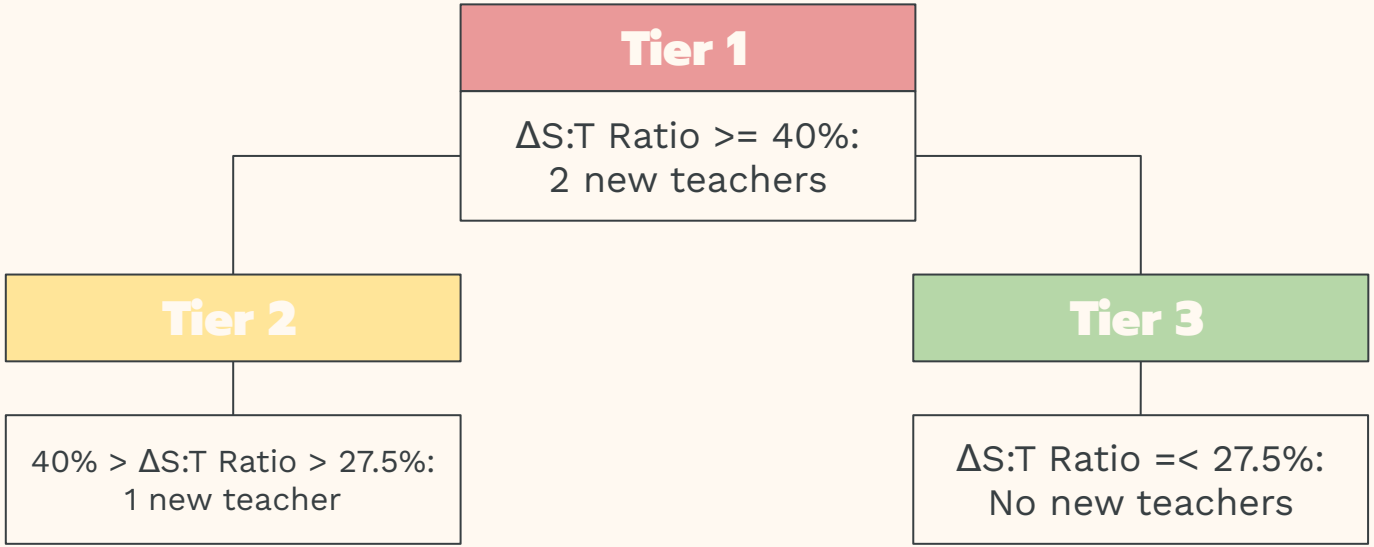
This graph shows the distribution of student:teacher ratios before and after expansion.



% Change in Ratios

Department	Student:Teacher Ratio	Student:Teacher Ratio (PREDICTED)	% Change
Math	108:1	134:1	24.07
Biology	80:1	120:1	50.00
Chemistry	98:1	117:1	19.39
Physics	97:1	110:1	13.40
English	98:1	128:1	30.61
Social Studies	75:1	105:1	40.00
Spanish French German	55:1 61:1 26:1	76:1 78:1 34.1	36.35 26.23 26.92
Art	99:1	126:1	27.27
Music	155:1	199:1	28.39

Teacher Allocation System



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Department	Student:Teacher Ratio	Student:Teacher Ratio (PREDICTED)	% Change
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Social Studies	75:1	105:1	40.00
Spanish French German	55:1 61:1 26:1	76:1 78:1 34.1	36.35 26.23 26.92
Art	99:1	126:1	27.27
Music	155:1	199:1	28.39

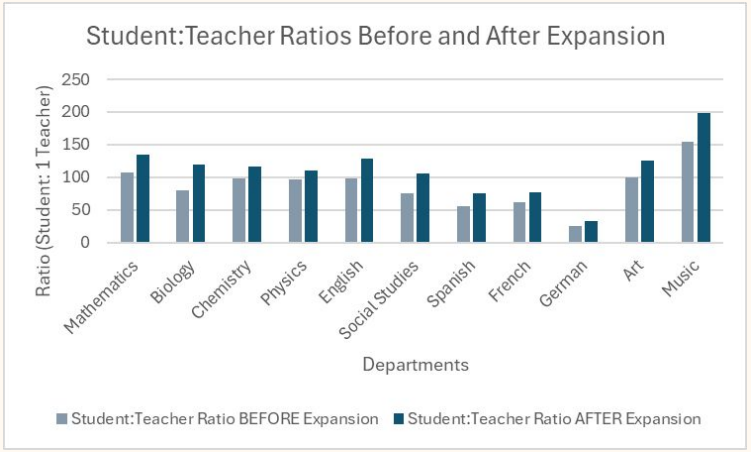
Resulting Teacher Allocations

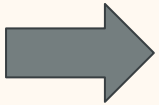
New teachers	No new teachers
Biology: 2 new teachers	**Math**
Language: 1 new Spanish + French	**Chemistry**
Social Studies: 2 New Teachers	**Physics**
English and Music: 1 new teacher each (Total 2)	**Art**

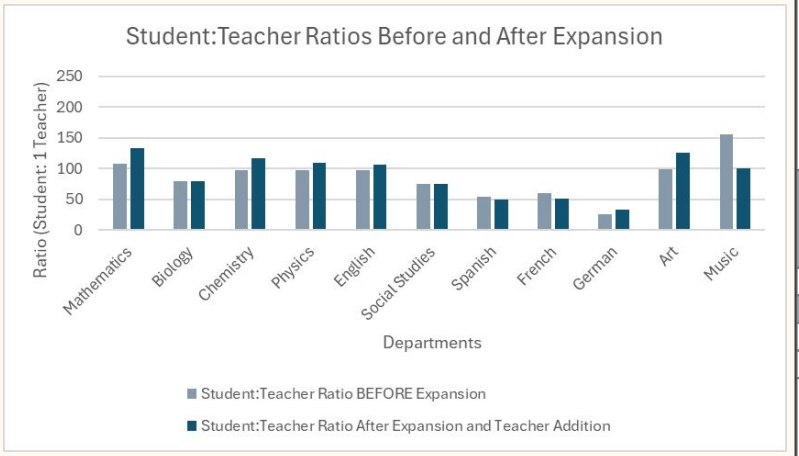
New Predicted Student : Teacher Ratios

Department	# of Students	# of Teachers	Student:Teacher Ratio
Math	804	6	134:1
Biology	482	6	80:1
Chemistry	351	3	117:1
Physics	330	3	110:1
English	644	6	107:1
Social Studies	527	7	75:1
Spanish French German	151 156 68	4 (3 Spanish, 2 French, 3 German)	50:1 52:1 34:1
Art	126	1	126:1
Music	199	2	100:1

STUDENT:TEACHER RATIOS







% Change in Ratios

Department	Student:Teacher Ratio	Student:Teacher Ratio (NEW)	% Change
Math	108:1	134:1	24.07
Biology	80:1	80:1	0.00
Chemistry	98:1	117:1	19.39
Physics	97:1	110:1	13.40
English	98:1	107:1	9.18
Social Studies	75:1	75:1	0.00
Spanish French German	55:1 61:1 26:1	50:1 77:1 23:1	-9.09 26.23 -11.54
Art	99:1	126:1	27.27
Music	155:1	100:1	-35.48

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CONCLUSION

Project Reflections

Reflection

What could we improve?

Let’s take a look at the percent change of the ratio after the new teachers were added:

Music:

Before Addition of Teachers: 28.39%

After Addition of Teachers: -35.48%

In this scenario, we are overcompensating the student-teacher ratio. This is also true for the languages of Spanish and German.

Are there possible solutions to further minimize the change in ratio when compared to the ratios of the 24-25 school year? Can we take some of this compensation and use it for Mathematics or Art?

Next Steps

Integrate Course Availability

We could take a deeper dive into what courses within each department are offered to students. For example, most Freshmen will not be taking AP Calculus BC, but maybe, some Seniors will.

Does Music include Band and Chorus?

This question would allow us to reconsider whether Music needs more teachers, as a band would have a large class size and higher student:teacher ratio in general. Therefore, -35% change is not required.

THANKS

Do you have any questions?

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WORKBOOK:

EpsilonSchoolMathModeling.xlsx