Euler School

—

Kaz Erdos, Daiwik Pal, Andy Hu breakout #4

Restatement

6	mathematics	5	English faculty	
3	chemistry faculty	3	foreign language faculty	
3	physics faculty	1	music instructor	
4	biology faculty	1	art instructor	
5	social studies faculty			

Departmental Enrollment Totals: September 2020

Department	10th	11th	12th	Total
Art	31	33	35	99
Biology	198	95	26	319
Chemistry	59	126	109	294
English	183	155	152	490
French	41	32	49	122
German	19	22	10	51
Spanish	51	26	33	110
Mathematics	184	201	262	647
Music	50	56	49	155
Physics	50	58	183	291
Social Studies	183	131	59	373

At the Euler School, which teaches 10th through 12th graders, **140** new sophomores will be added for the 2020-2021 school year, which will differ from the usual amount of new sophomores, which is exactly equal to the departing seniors. **Seven** new faculty will be hired, and the problem is to decide **which departments** will receive these teachers in the most fair way possible. It must also be taken into account that **5%** of sophomores will drop out before they graduate.

Summary of work

1. Find the ratio of classes taken to students
2. Get how many students and classes there will be for the 2021 school year
3. Find the number of classes taken for each subject for 2021 school year
4. Calculate number of students per teacher for each subject for 2020 and 2021
5. Calculate the percent change in students per teacher for each subject from 2020 to 2021
6. Identify subjects with highest percent change and add the 7 teachers to minimize overall avg change from 2020-2021

Assumptions/hypothesis (even if "obvious")

- Every student takes about the same number of classes

- Current language teachers can teacher 2 classes
  - Can be unequal distribution, not just 50/50

- 5% decrease happens equally over 3 years

- Music and Art teachers can handle more students at once

- Course trends between grades stay constant

- Numbers are rounded when necessary

- 2020 school year went well

- Preparation is done for beginning of year (before dropouts)

Analysis of problem

- Major Changes in Department Enrollment Totals 2020:
  - Rapid Decrease in Biology and Social Studies
  - Languages, Art, and Musics are steady
  - Mathematics and Physics grow rapidly
- Total Students increases by 140 students or 29% increase from 490 to 630
- **Goal: to have the least change in number of students taught for all teachers**

Department Enrollment Totals: 2020
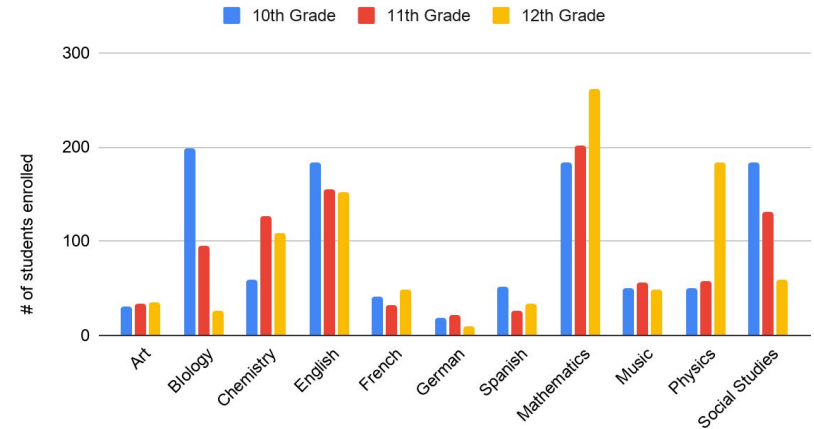
Ratio of students to classes taken

Data for 2020-2021 school year

Department	10th	11th	12th	total
Art	31	33	35	99
BIology	198	95	26	319
Chemistry	59	126	109	294
English	183	155	152	490
French	41	32	49	122
German	19	22	10	51
Spanish	51	26	33	110
Mathematics	184	201	262	647
Music	50	56	49	155
Physics	50	58	183	291
Social Studies	183	131	59	373
Total	1049	935	967	2951

$1049 + 935 + 967 = $ x(Sophomore + Junior + Senior)

$2951 = 490x$

$X = 6.022449$

Ratio of students to classes(1:6.022449)

Sophomore class
- Around 174.18163 students round to 174

Junior class
- Around 155.25246 students round to 155

Senior class
- Around 160.56591 students round to 161

Therefore, incoming 2021 sophomore class will have around 314 (174+140) students

Number of students per grade 2021

Sophomore class of 2020 spends 3 total years in Euler high school

- ⅓ of 5% or 5/300 of sophomore class will drop out by beginning of 2021 for 171.1 students

For 2020 Juniors it is more complicated:

- J = 295*S/300
- S = 300*J/295
- S = 300*155/295
- 2019 Sophomore class = 157.63 students
- ⅔ of 2019 sophomore class dropouts will occur by beginning of 2021 senior year
- ⅔ of 5% or 10/300 of 2019 sophomore class will be 152.37 students(rounded)

Estimating Number of Classes Taken for 2021 School Year

- New values can be found through Ratios from 2020 year
- **Example: 10th grade Art**
  - $\dfrac{2021\ 10th\ Grade\ Art}{2021\ 10th\ Grade\ Total} = \dfrac{2020\ 10th\ Grade\ Art}{2020\ 10th\ Grade\ Tot\alpha}$
  - $\dfrac{x}{314} = \dfrac{31}{174}$
  - $x = 55.94$

Department	10th	11th	12th	total
Art	55.94	36.43	33.12	125.49
BIology	357.31	104.87	24.61	486.78
Chemistry	106.47	139.09	103.16	348.72
English	330.24	171.10	143.86	645.20
French	73.99	35.32	46.37	155.69
German	34.29	24.29	9.46	68.04
Spanish	92.03	28.70	31.23	151.97
Mathematics	332.05	221.88	247.96	801.88
Music	90.23	61.82	46.37	198.42
Physics	90.23	64.02	173.19	327.45
Social Studies	330.24	144.61	55.84	530.69
Total	1893.02	1032.12	915.18	3840.33

Special Case: Language Classes

Department(2020-2021)	10th	11th	12th	total
French	41	32	49	122
German	19	22	10	51
Spanish	51	26	33	110
Department(2021-2022)	10th	11th	12th	total
French	73.99	35.32	46.37	155.69
German	34.29	24.29	9.46	68.04
Spanish	92.03	28.70	31.23	151.97

Special Case: Language Classes

Class (2020)	Teachers
French	1.3
German	0.55
Spanish	1.15

Example: French (2020)

- $\frac{\text{total \# of students taking french}}{\text{total \# of students taking languages}} \cdot \text{\# of language teachers}$
- $\frac{122}{283} \cdot 3$
- 1. 29 (round to 1.3)

Class (2021)	Teachers
French	2
German	1
Spanish	2

Finding # of teachers to add:

- $\frac{\text{total \# of students taking french}}{\text{total \# of students taking languages}} \cdot \text{\# of language teachers}$
- $\frac{155.69}{375.69} \cdot 5$
- 2.07 (round to 2) - therefore adding .7

Calculating change for students taught per teacher

Class(2020)	Teachers	Students taught per teacher
Art	1	99
Bio	4	79.75
Chem	3	98
English	5	98
French	1.3	93.85
German	0.55	92.73
Spanish	1.15	95.65
Math	6	107.83
Music	1	155
Physics	3	97
Social Studies	5	74.6

Class(2021)	Teachers	Students taught per teacher
Art	1	125.49
Bio	4	121.70
Chem	3	116.24
English	5	129.04
French	1.3	119.76
German	0.55	123.70
Spanish	1.15	132.15
Math	6	133.65
Music	1	198.42
Physics	3	109.15
Social Studies	5	106.14

Class	Change in # of class enrollments
Art	26.49
Bio	41.95
Chem	18.24
English	31.04
French	25.91
German	30.98
Spanish	36.49
Math	25.81
Music	43.42
Physics	12.15
Social Studies	31.54

|2021 students taught per teacher - 2020 students taught per teacher| = Change

Identify Highest Change and Add 7 Teachers Accordingly

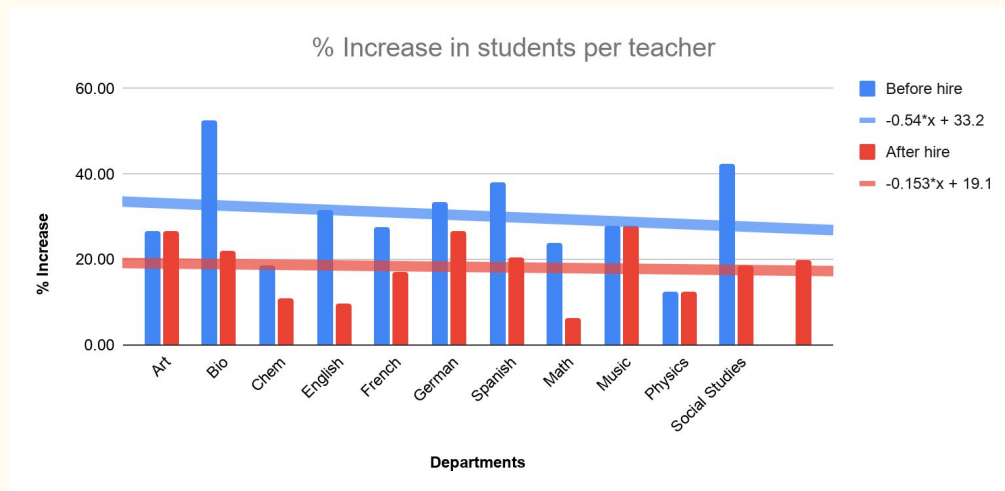|	Before Hiring	After Hiring
Average Change	33.6%	19.9%

Change in % (by department):

$$\frac{\left(\frac{2021\ students}{2021\ \#\ of\ teachers} - \frac{2020\ students}{2020\ \#\ of\ teachers}\right)}{\frac{2020\ students}{2020\ \#\ of\ teachers}} \cdot 100$$

Percentage change in class enrollment size

- Average Percentage:

$$\frac{\left(\sum |percentages|\right)}{10}$$
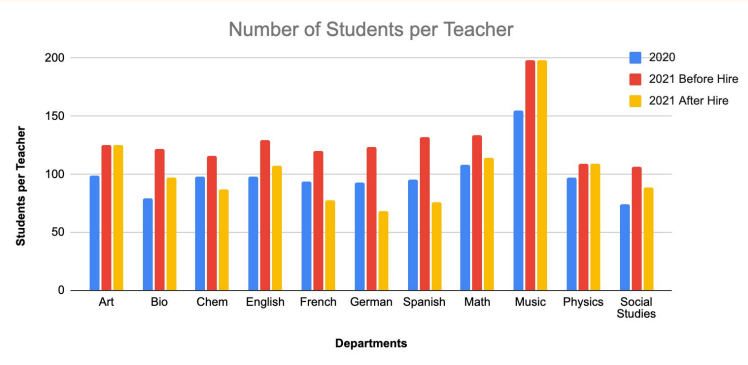

% Increase in students per teacher

Justification
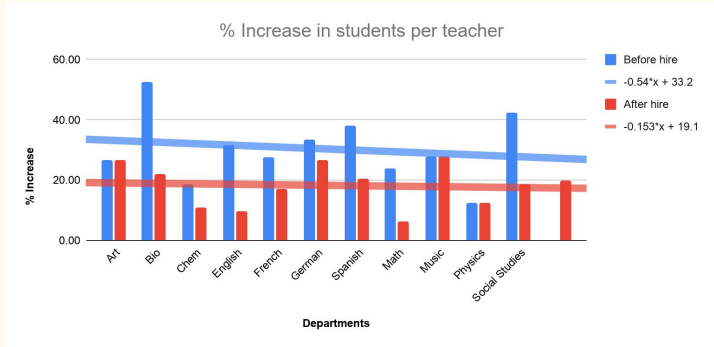
Both charts justify our model and solution since they demonstrate the improvement made for the teachers by the model

First chart: Red trendline lower and flatter than blue trendline - GOOD!

Second chart: Summarizes results

Solution

1 teacher to bio, chemistry, english, math, social studies.

2 teachers to lang department.

First new teacher teaches 70% French and 30% Spanish

Second new teacher teaches 45% German and 55% Spanish

Strengths / Weaknesses

Strengths:	Weakness:
- Purely objective and based on numbers - Very modular, can be changed on the fly - Results easy justifiable by quantitative data (% change) - Assumptions are logical	- Relies on smart amount of data given for 2020 school year - Depends on a few key assumptions - Numbers had to be rounded - Language teacher percentages unrealistic - Puts high strain on Music/Art teachers

Error Analysis

- Shown are each department's deviation from the average %change in classes per teacher
- Average deviation is very close to 0

Course data for any given 2020 grade level can be a "fluke" which would throw off our whole model

Deviation
6.84
2.16
-8.88
-10.19
-2.87
6.71
0.64
-13.69
8.09
-7.39
-1.36
-1.81

Robustness and Stability

- When deciding where to put teachers based on percentage change values, we simply went by the largest percent increases.
- For beyond the 2021-2022 school year, teachers we decided to hire based on our model will not work as well
    - For example, bio department will see decrease in enrollments 2022-2023 whereas chemistry will see increase.
    - We advise the school to encourage students to take courses to fit the new faculty population

Any Questions?

Justification

Pulled from our model of predictions for number of classes taken shown previously

For each of the 3 grade levels for both 2020 and 2021:

    Tested our model by dividing total classes per grade level by number of students per grade level.

Each result is very close to 6

Confirms our model because:

- All answers are very close

- Original estimate for classes/student was around 6

1049	classes 10th 2020	6.028735632	classes/student
935	classes 11th 2020	6.032258065	classes/student
967	classes 12 2020	6.00621118	classes/student
1893.02	classes 10th 2021	6.028735632	classes/student
1032.12	classes 11th 2021	6.032258065	classes/student
915.18	classes 12th 2021	6.00621118	classes/student