Epsilon School of Mathematics and Science

Nick Giza, Armaan Priyadarshan, Timothy Schowalter, Ethan Zhou

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Context/Problem Statement

The Epsilon School of Mathematics and Science is expanding to be able to hold 630 students, as opposed to the prior capacity of 490 students. In order to facilitate this expansion, they will be hiring 7 additional teachers.

How can the 7 new teachers be distributed among the school's 9 departments in order to best serve the school and the student body?

Assumptions & Justification

Assumptions:

- All students take one English class per year
- The dropout rate was consistent throughout every year
- Each grade maintains the same subject enrollment ratio from year to year
- All teachers have the same number of classes
- The enrollments-teacher ratios from last year were ideal

Problem Analysis

- Objective: Make the enrollment to teacher ratio as close as possible to the previous year
- Uses assumption that teachers were hired in such a way to best fit the needs of the previous years' student body
- Our model aims to extrapolate the previous years' ratio onto the size of the new student body to best serve this year's student body

Variables

Variables:

- Enrollments per teacher (New and Past)
- Subject enrollments (New and Past)
- Grade size (New and Past)
- Subject enrollment to total ratio = subject enrollment / total enrollment
- Enrollment per teacher difference = Enrollments per teacher (New) – enrollment per teacher (Past)

Hypothesis

Based on the subject enrollments and teacher counts, it is likely that the Math and Music departments will need additional teachers due to the high student to teacher ratios

Current Class Sizes

- We then found the size of each grade from the previous year by looking at the enrollments for English classes
  - We made this assumption since the total number of English enrollments was equal to the number of students and resultant grade sizes were distributed reasonably
- To find the new grade size, we had to factor in the 5% dropout rate and the additional 140 incoming sophomores

Subject	10th grade	11th grade	12th grade	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

New Class Sizes

- We assumed that the dropout rate was equal across each grade, so (5%)*(⅓) of each grade dropped out over the 2023 school year
- Using the exponential decay formula (class size)*(1 - 0.05*⅓), we found the 2023 class sizes after dropouts
- The incoming sophomore class was found after applying this formula to the graduating senior class and adding 140

	Class sizes after dropouts
10th grade:	289
11th grade:	180
12th grade:	152
Total enrollment:	621
Total Dropouts:	9 dropouts

The new 11th grade and 12th grades are the size of the respective 10th and 11th grade classes from 2023 after applying the formula. The new 10th grade is the size of the 2023 senior class after applying the formula and adding 140.

Past Subject to Grade Ratios

- Our model then divided the previous year's enrollments per subject for each grade by the sum of all enrollments for that grade to find **what fraction of the grade took each subject**.

Subject	10th grade	11th grade	12th grade	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
Totals:	1049	935	967	2951

subject/total 10th	subject/total 11th	subject/total 12th
0.03	0.04	0.04
0.19	0.10	0.03
0.06	0.13	0.11
0.17	0.17	0.16
0.04	0.03	0.05
0.02	0.02	0.01
0.05	0.03	0.03
0.18	0.21	0.27
0.05	0.06	0.05
0.05	0.06	0.19
0.17	0.14	0.06

Subject Enrollments for the New Class

- Using the **new** class sizes, we multiplied them by the each ratio of subject enrollments to total enrollments for the previous year's class and the average enrollments per student to find the new subject enrollments for each class.

	New 10th grade	New 11th grade	New 12th grade	Total
Art	49	38	35	122
Biology	313	110	26	449
Chemistry	93	146	109	348
English	289	180	152	621
French	65	37	49	151
German	30	26	10	66
Spanish	81	30	33	144
Mathematics	291	233	262	786
Music	79	65	49	193
Physics	79	67	183	329
Social Studies	289	152	59	500

Consistent with the assumption that all students take exactly one english class

Solution

- A system of demand was established by looking at the greatest difference between this year's enrollment-teacher ratio and last year's enrollment-teacher ratio
- Teachers were added one at a time to the subject with the greatest enrollment difference between the two years

Subject	New teacher totals	New hires
Art	2	1
Biology	5	1
Chemistry	3	0
English	6	1
French	1.5	
German	1	
Spanish	1.5	1
Mathematics	7	1
Music	2	1
Physics	3	0
Social Studies	6	1

Justification & Testing

- Our model logically compares the enrollment to teacher ratios of the previous year and the current year to ensure consistency throughout the two years
- It optimizes the ratio so that the enrollment to teacher difference is minimal
- A possible way to test this model would be to compare the enrollment to teacher difference of our scenario with a scenario where seven teachers were hired at random

Enrollment to teacher difference	Enrollment to teacher difference with no hires	Enrollment to teacher difference with random hires	Random hires	Random new teacher totals
-37.86	23.28	118.28	3	4
10.05	32.50	444.01	1	5
18.17	18.17	345.50	0	3
5.50	26.20	616.00	0	5
-4.28	25.73	357.20	0	3
4.45	23.17	779.00	1	7
-58.50	37.99	191.99	0	1
12.77	12.77	326.32	0	3
8.75	25.43	493.13	2	7

Language Teachers

- If we consider the language department as a whole, demand called for one additional teacher
- Using the same method of matching enrollments per teacher to last year's values, we determined an optimal distribution of 1.5 : 1 : 1.5 teachers among French, German and Spanish, where 0.5 of a teacher represents a teacher spending half their time teaching that language and half their time teaching another
- This distribution can be achieved by hiring one additional teacher regardless of the previous distribution

Strengths and Weaknesses

Strengths

- Normalized the enrollment to teacher ratio for each subject
- Factored in the dropout rate
- Optimized the distribution within the language department

Weaknesses

- Lost precision due to assumptions:
  - Old class sizes
  - Equal dropout rates across grades
  - Subject enrollment
  - Subject importance
  - Previous ratios were ideal

Questions?

We gotchu