Approach for Placing Schools into a Math Is Cool Division

Summary

The intent of the Math Is Cool (MIC) division scheme is (and has been) to have divisions where schools are competing against other schools of similar experience/skill level. From our extensive discussions MIC staff are aware that optimally defining divisions isn't a simple task. However, the current approach is viewed as an improvement over the previous approach that was based on whether a school was in a large school district versus a small school district. In the current approach, MIC divisions are determined based primarily on past performance, with some leeway for Regional Directors to account for new schools and schools exhibiting certain characteristics (e.g., magnet schools). Because past performance is used as the key metric for placement, there will always be some schools that just make it into a particular division (or just miss a particular division)—that is inherent in the approach. But, divisions are reassigned annually, with some constraints on movement between divisions from year-to-year. Those constraints, and using an average performance over the past 4 years, are intended to place schools in appropriate divisions, despite a school having a year where the participants are particularly strong or not so strong. Specifics of division placement are given below, along with an example.

Based on average performance over the past four years, elementary and middle schools are binned into one of the four MIC divisions (i, ϕ, e, and π), while high schools are placed into 3 divisions (i, ϕ, and e). New schools without historical performance data are placed into a division by the Regional Director. The performance metric is based on a "percentile rank," which is used to normalize results from year-to-year. Percentile rank represents the relative performance of a school versus all other schools participating in Math Is Cool Championships at a particular grade level in a given year. The average percentile rank for a specific school is calculated using all data over the past four years for all grades in the associated grade level categories. Grade levels are divided into categories of: 4/5, 6, 7/8, and H.S. Thus, for example, an elementary school would typically have percentile data for both 4th and 5th grades, which will be used in the average percentile calculation for the 4/5 grade level category. Note that 6th grade is identified as its own category because some schools have 6th grade as part of the elementary school and some as part of a middle school.

Using the set of average percentile data (calculated as described above) for all schools that have participated in MIC in the past four years, schools are binned into the different divisions to give about 17-22% of the schools in Division i and 25-30% of schools in each of the other three divisions, depending on the number of participating schools in a given year. With high school only having three divisions, the distribution is 20-30% in Division i, and 35-40% in the other two divisions.

There are, however, several constraints on the direct use of the calculated average percentile. A school cannot move up or down by more than one division from year to year. There is also a "buffer" applied. If the average percentile for a school is an increase over the prior year, but is less than 2 percent above the point where the school would move up to a higher division, then the school will remain in their current division. Similarly, if the average percentile is less than 1 percent below the point where the school would move down a division, then the school will remain in their current division. Finally, the Regional Director has some discretion to override division assignments in special cases.

Example Calculation

A small arbitrary data set is used to illustrate the percentile calculation. Pretend that only 19 schools across the state participated in Math Is Cool in the 2013-14 school year at the 7th grade level. Scores are sorted in decreasing order and the percentile is calculated for the ith school per Equation 1, where N = number of schools in the grade level. Table 1 lists the example data and the calculated percentile values.

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$$Percentile_{i} = \frac{\left(\sum_{j=1}^{N} If\left(Score_{i} < Score_{j},1,0\right)\right) + 0.5 \cdot \left(\sum_{j=1}^{N} If\left(Score_{i} = Score_{j},1,0\right)\right)}{N} \qquad (1)$$

Table 1. Example Data Set for 7th Grade Championships Scores in the 2013-14 School Year

School Name	Grade	Champs. Score 2013-14	Percentile
Browne J.H.	7	160	0.974
Buffon Academy	7	155	0.921
Eho's Academy of Academics	**7**	**145**	**0.868**
Hopper J.H.	7	130	0.789
Mirzakhani M.S.	7	130	0.789
Fermat J.H.	7	128	0.711
Blum M.S.	7	124	0.658
Fawcett J.H.	7	112	0.605
Biffington Middle School	**7**	**105**	**0.553**
Blanch M.S.	7	101.5	0.500
Germain M.S.	7	90	0.447
Newton M.S.	7	87	0.395
Todd M.S.	7	83	0.342
Leibnitz J.H.	7	80	0.289
Lovelace M.S.	7	70	0.237
Boole M.S.	7	59	0.184
Chang M.S.	7	54	0.132
Euler M.S.	7	50	0.079
Gauss M.S.	7	22	0.026

The Table 1 percentile results for the two schools in bold are combined with additional data to show, in Table 2, calculation of the average percentile rank over the relevant grades and the past four years. The average percentile is used to determine the appropriate division. In special circumstances, the Regional Director may override the calculated division. For example, Erdős Elementary 6th grade has only competed for one year and they aren't a magnet school, so the Regional Director decided to leave them in Division ϕ for the current year. As school new to MIC, Bernoulli M.S. is placed in Division e. Mable's Math Magnet School is a magnet school, so the Regional Director places them in Division i.

Table 2. Example Division Calculations

School Name	Grade	Percentile Rank 2013-14	2014-15	2015-16	2016-17	Number of Observations	Average Percentile Rank	Calculated Division	Division Override	Assigned Division
Erdős Elementary	4	0.321	0.417	0.413	0.385	7	0.429	e		e
Erdős Elementary	5		0.562	0.478	—					
Erdős Elementary	6	—	—	—	0.854	1	0.854	i	ϕ	ϕ
Eho's Academy of Academics	7	**0.868**	0.845	0.898	0.926	8	0.906	i		i
Eho's Academy of Academics	8	0.958	0.938	0.834	0.983					
Biffington Middle School	7	**0.553**	—	0.728	0.521	6	0.642	ϕ		ϕ
Biffington Middle School	8	0.622	0.688	—	0.742					
Mable's Math Magent School	8	—	—	—	—	0	—	—	i	i
Bernoulli Middle School	6	—	—	—	—	0	—	—	e	e

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