Class Scheduling through Linear Programming

By Amber Rosacker

Class Scheduling + TimeTabling

Determine which teacher teaches what class when

- Only one class, and time per teacher
- Classrooms
- Taking preferences of classes into account

What this looks like at the moment:

Teachers fill out a sheet that asks:

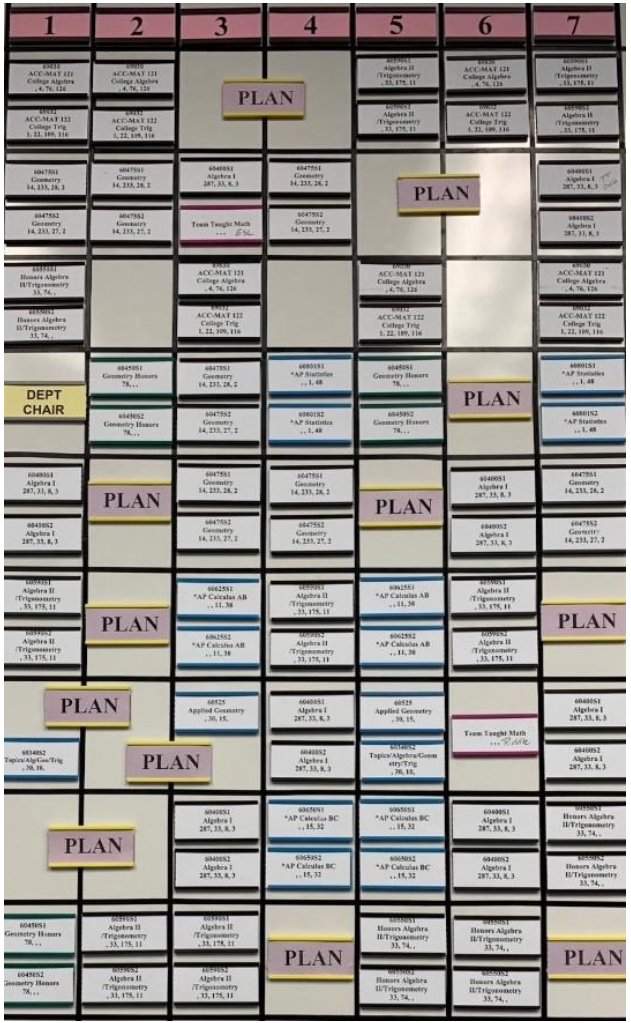
- Top 5 classes we would like to teach (ranked 1 - 5)
- What off periods we prefer
- Any other special requests we have

- 10 departments
- About 100 total staff
- One admin sorts/builds

This is about 1/15 of the whole board that is built

Takes a whole semester

If something needs to change, it causes a lot of problems



What a teacher's Schedule looks like

Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Period 7
Honors Geometry	Algebra 2/Trig	Algebra 2/Trig	Plan	Honors Algebra 2/Trig	Honors Algebra 2/Trig	Plan

The model:

I created a model that assigns 5 teachers to 5 classes that have to occur at different times during the day.

The AMPL Model

```
set TEACHERS;
set CLASSROOMS;
set CLASSES;
set TIMES;

param classpref {CLASSES, TEACHERS} > 0;


var Assign {TEACHERS, CLASSES, TIMES} binary;


minimize Total:
sum {t in TEACHERS} sum{l in CLASSES} sum{i in TIMES} classpref[l,t]*Assign[t,l,i] ;

#optimized the best scheduled based on minimizing each teacher's class preference

subject to EveryClassTaught {l in CLASSES} :
sum {t in TEACHERS} sum {i in TIMES} Assign[t,l,i] =1;
    #Every class has to be taught

subject to OneTeacherPerClass {t in TEACHERS, i in TIMES}:
sum{l in CLASSES} Assign[t,l,i] <= 1 ;
    #Each teacher can only teach at most one class at any given time

subject to 5MaxClasses {t in TEACHERS} :
sum {l in CLASSES} sum{i in TIMES} Assign[t,l,i] <= 5;
    #Each teacher can only teach up to 5 classes
```

The AMPL Model : Data

```
set TEACHERS := Rosacker Smith Johnson McIlroy Davis ;

set CLASSROOMS := 2610 2620 2630 2640 2650 ;

set CLASSES := Algebra1 Algebra1a Algebra1b Algebra1c Algebra1d Algebra1e
Geometry Geometrya Geometryb Geometryc Geometryd Geometrye
Algebra2 Algebra2a Algebra2b Algebra2c Algebra2d CollegeAlg CollegeAlga
CollegeAlgb CollegeAlgc Trig Triga Trigb Trigc ;

set TIMES := 1st 2nd 3rd 4th 5th 6th 7th ;
```

```
param classpref: Rosacker Smith Johnson McIlroy Davis :=
Algebra1          3       4       3       1       2
Algebra1a         3       4       3       1       2
Algebra1b         3       4       3       2       1
Algebra1c         3       4       3       2       1
Algebra1d         3       4       3       2       1
Algebra1e         3       4       3       2       2
Geometry          1       2       5       5       5
Geometrya         1       2       5       5       5
Geometryb         1       2       5       5       5
Geometryc         2       1       5       5       5
Geometryd         2       1       5       5       5
Geometrye         2       2       5       5       1
Algebra2          1       5       2       3       2
Algebra2a         1       5       2       3       2
Algebra2b         2       5       1       3       2
Algebra2c         2       5       1       3       2
Algebra2d         2       5       1       3       2
CollegeAlg        5       2       1       4       3
CollegeAlga       5       1       2       4       3
CollegeAlgb       5       1       1       4       3
CollegeAlgc       5       1       2       4       3
Trig              4       3       4       2       1
Triga             4       3       4       1       5
Trigb             4       3       4       1       5
Trigc             4       3       4       1       5 ;
```

Results

```
CPLEX 12.9.0.0: optimal integer solution; objective 27
38 MIP simplex iterations
0 branch-and-bound nodes
```

The 1's represent a class and time the teacher will teach!

Assign [Davis,*,*]

:	1st	2nd	3rd	4th	5th	6th	7th	:=
Algebra1	0	0	0	0	0	0	0	
Algebra1a	0	0	0	0	0	0	0	
Algebra1b	1	0	0	0	0	0	0	
Algebra1c	0	0	0	0	0	1	0	
Algebra1d	0	0	0	1	0	0	0	
Algebra1e	0	0	0	0	0	0	0	
Algebra2	0	0	0	0	0	0	0	
Algebra2a	0	0	0	0	0	0	0	
Algebra2b	0	0	0	0	0	0	0	
Algebra2c	0	0	0	0	0	0	0	
Algebra2d	0	0	0	0	0	0	0	
CollegeAlg	0	0	0	0	0	0	0	
CollegeAlga	0	0	0	0	0	0	0	
CollegeAlgb	0	0	0	0	0	0	0	
CollegeAlgc	0	0	0	0	0	0	0	
Geometry	0	0	0	0	0	0	0	
Geometrya	0	0	0	0	0	0	0	
Geometryb	0	0	0	0	0	0	0	
Geometryc	0	0	0	0	0	0	0	
Geometryd	0	0	0	0	0	0	0	
Geometrye	0	1	0	0	0	0	0	
Trig	0	0	1	0	0	0	0	
Triga	0	0	0	0	0	0	0	
Trigb	0	0	0	0	0	0	0	
Trigc	0	0	0	0	0	0	0	

[Johnson,*,*]

:	1st	2nd	3rd	4th	5th	6th	7th	:=
Algebra1	0	0	0	0	0	0	0	
Algebra1a	0	0	0	0	0	0	0	
Algebra1b	0	0	0	0	0	0	0	
Algebra1c	0	0	0	0	0	0	0	
Algebra1d	0	0	0	0	0	0	0	
Algebra1e	0	0	0	0	0	1	0	
Algebra2	0	0	0	0	0	0	0	
Algebra2a	0	0	0	0	0	0	0	
Algebra2b	1	0	0	0	0	0	0	
Algebra2c	0	0	0	0	1	0	0	
Algebra2d	0	0	1	0	0	0	0	
CollegeAlg	0	1	0	0	0	0	0	
CollegeAlga	0	0	0	0	0	0	0	
CollegeAlgb	0	0	0	0	0	0	0	
CollegeAlgc	0	0	0	0	0	0	0	
Geometry	0	0	0	0	0	0	0	
Geometrya	0	0	0	0	0	0	0	
Geometryb	0	0	0	0	0	0	0	
Geometryc	0	0	0	0	0	0	0	
Geometryd	0	0	0	0	0	0	0	
Geometrye	0	0	0	0	0	0	0	
Trig	0	0	0	0	0	0	0	
Triga	0	0	0	0	0	0	0	
Trigb	0	0	0	0	0	0	0	
Trigc	0	0	0	0	0	0	0	

[McIlroy,*,*]

:	1st	2nd	3rd	4th	5th	6th	7th
Algebra1	1	0	0	0	0	0	0
Algebra1a	0	0	0	0	0	0	1
Algebra1b	0	0	0	0	0	0	0
Algebra1c	0	0	0	0	0	0	0
Algebra1d	0	0	0	0	0	0	0
Algebra1e	0	0	0	0	0	0	0
Algebra2	0	0	0	0	0	0	0
Algebra2a	0	0	0	0	0	0	0
Algebra2b	0	0	0	0	0	0	0
Algebra2c	0	0	0	0	0	0	0
Algebra2d	0	0	0	0	0	0	0
CollegeAlg	0	0	0	0	0	0	0
CollegeAlga	0	0	0	0	0	0	0
CollegeAlgb	0	0	0	0	0	0	0
CollegeAlgc	0	0	0	0	0	0	0
Geometry	0	0	0	0	0	0	0
Geometrya	0	0	0	0	0	0	0
Geometryb	0	0	0	0	0	0	0
Geometryc	0	0	0	0	0	0	0
Geometryd	0	0	0	0	0	0	0
Geometrye	0	0	0	0	0	0	0
Trig	0	0	0	0	0	0	0
Triga	0	0	0	0	1	0	0
Trigb	0	1	0	0	0	0	0
Trigc	0	0	0	0	0	1	0

:=

[Rosacker,*,*]

:	1st	2nd	3rd	4th	5th	6th	7th
Algebra1	0	0	0	0	0	0	0
Algebra1a	0	0	0	0	0	0	0
Algebra1b	0	0	0	0	0	0	0
Algebra1c	0	0	0	0	0	0	0
Algebra1d	0	0	0	0	0	0	0
Algebra1e	0	0	0	0	0	0	0
Algebra2	0	0	1	0	0	0	0
Algebra2a	0	1	0	0	0	0	0
Algebra2b	0	0	0	0	0	0	0
Algebra2c	0	0	0	0	0	0	0
Algebra2d	0	0	0	0	0	0	0
CollegeAlg	0	0	0	0	0	0	0
CollegeAlga	0	0	0	0	0	0	0
CollegeAlgb	0	0	0	0	0	0	0
CollegeAlgc	0	0	0	0	0	0	0
Geometry	1	0	0	0	0	0	0
Geometrya	0	0	0	0	0	0	1
Geometryb	0	0	0	0	1	0	0
Geometryc	0	0	0	0	0	0	0
Geometryd	0	0	0	0	0	0	0
Geometrye	0	0	0	0	0	0	0
Trig	0	0	0	0	0	0	0
Triga	0	0	0	0	0	0	0
Trigb	0	0	0	0	0	0	0
Trigc	0	0	0	0	0	0	0

[Smith,*,*]

:	1st	2nd	3rd	4th	5th	6th	7th
Algebra1	0	0	0	0	0	0	0
Algebra1a	0	0	0	0	0	0	0
Algebra1b	0	0	0	0	0	0	0
Algebra1c	0	0	0	0	0	0	0
Algebra1d	0	0	0	0	0	0	0
Algebra1e	0	0	0	0	0	0	0
Algebra2	0	0	0	0	0	0	0
Algebra2a	0	0	0	0	0	0	0
Algebra2b	0	0	0	0	0	0	0
Algebra2c	0	0	0	0	0	0	0
Algebra2d	0	0	0	0	0	0	0
CollegeAlg	0	0	0	0	0	0	0
CollegeAlga	0	1	0	0	0	0	0
CollegeAlgb	0	0	0	0	0	0	1
CollegeAlgc	0	0	1	0	0	0	0
Geometry	0	0	0	0	0	0	0
Geometrya	0	0	0	0	0	0	0
Geometryb	0	0	0	0	0	0	0
Geometryc	1	0	0	0	0	0	0
Geometryd	0	0	0	0	1	0	0
Geometrye	0	0	0	0	0	0	0
Trig	0	0	0	0	0	0	0
Triga	0	0	0	0	0	0	0
Trigb	0	0	0	0	0	0	0
Trigc	0	0	0	0	0	0	0

:=

;

Extensions

- Better way to do class sections
- Extend this to 15 teachers and corresponding classes/times
- Max of 4 teacher per each class
- Only 3 different class types max per teacher
- There needs to be one of each section for each course during different time periods (All Alg 1’s can’t be 1st period)
- Need to have one plan period on an even period & one plan period on an odd period
- And so many more…

I THEN TRIED TO RUN IT AS A LINEAR PROGRAM - NOT BINARY

```
set TEACHERS;
set CLASSROOMS;
set CLASSES;
set TIMES;

param classpref {CLASSES, TEACHERS} > 0;


var Assign {TEACHERS, CLASSES, TIMES} >=0, <=1;



minimize Total:
sum {t in TEACHERS} sum{l in CLASSES} sum{i in TIMES} classpref[l,t]*Assign[t,l,i] ;

#optimized the best scheduled based on minimizing each teacher's class preference


subject to OneTeacherPerClass {t in TEACHERS, i in TIMES}:
sum{l in CLASSES} Assign[t,l,i] <= 1 ;
    #Each teacher can only teach at most one class at any given time

subject to EveryClassTaught {l in CLASSES} :
sum {t in TEACHERS} sum {i in TIMES} Assign[t,l,i] =1;
    #Every class has to be taught


subject to 5MaxClasses {t in TEACHERS} :
sum {l in CLASSES} sum{i in TIMES} Assign[t,l,i] <= 5;
    #Each teacher can only teach up to 5 classes
```

This still assigned the same teacher to the same classes to teach, but assigned them to different times throughout the day

Assign [Davis,*,*]

:	1st	2nd	3rd	4th	5th	6th	7th	:=
Algebra1	0	0	0	0	0	0	0	
Algebra1a	0	0	0	0	0	0	0	
Algebra1b	0	1	0	0	0	0	0	
Algebra1c	1	0	0	0	0	0	0	
Algebra1d	0	0	0	0	0	1	0	
Algebra1e	0	0	0	0	0	0	0	
Algebra2	0	0	0	0	0	0	0	
Algebra2a	0	0	0	0	0	0	0	
Algebra2b	0	0	0	0	0	0	0	
Algebra2c	0	0	0	0	0	0	0	
Algebra2d	0	0	0	0	0	0	0	
CollegeAlg	0	0	0	0	0	0	0	
CollegeAlga	0	0	0	0	0	0	0	
CollegeAlgb	0	0	0	0	0	0	0	
CollegeAlgc	0	0	0	0	0	0	0	
Geometry	0	0	0	0	0	0	0	
Geometrya	0	0	0	0	0	0	0	
Geometryb	0	0	0	0	0	0	0	
Geometryc	0	0	0	0	0	0	0	
Geometryd	0	0	0	0	0	0	0	
Geometrye	0	0	0	1	0	0	0	
Trig	0	0	0	0	1	0	0	
Triga	0	0	0	0	0	0	0	
Trigb	0	0	0	0	0	0	0	
Trigc	0	0	0	0	0	0	0	

Assign [Davis,*,*]

:	1st	2nd	3rd	4th	5th	6th	7th	:=
Algebra1	0	0	0	0	0	0	0	
Algebra1a	0	0	0	0	0	0	0	
Algebra1b	1	0	0	0	0	0	0	
Algebra1c	0	0	0	0	0	1	0	
Algebra1d	0	0	0	1	0	0	0	
Algebra1e	0	0	0	0	0	0	0	
Algebra2	0	0	0	0	0	0	0	
Algebra2a	0	0	0	0	0	0	0	
Algebra2b	0	0	0	0	0	0	0	
Algebra2c	0	0	0	0	0	0	0	
Algebra2d	0	0	0	0	0	0	0	
CollegeAlg	0	0	0	0	0	0	0	
CollegeAlga	0	0	0	0	0	0	0	
CollegeAlgb	0	0	0	0	0	0	0	
CollegeAlgc	0	0	0	0	0	0	0	
Geometry	0	0	0	0	0	0	0	
Geometrya	0	0	0	0	0	0	0	
Geometryb	0	0	0	0	0	0	0	
Geometryc	0	0	0	0	0	0	0	
Geometryd	0	0	0	0	0	0	0	
Geometrye	0	1	0	0	0	0	0	
Trig	0	0	1	0	0	0	0	
Triga	0	0	0	0	0	0	0	
Trigb	0	0	0	0	0	0	0	
Trigc	0	0	0	0	0	0	0	

Thank you! Questions?