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A Linear Programming Model for Scheduling Medical School Clinical Experience

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May 23, 2016

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HEALTHCARE ENGINEERING & PATIENT SAFETY
UNIVERSITY OF MICHIGAN

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"The Low Hanging Fruit"

- Some scheduling issues are mathematically simple
- Good relationships with collaborators, knowledge of the problem are essential
- Solved by a team of undergraduates in a few weeks during the school year
- Tangible impact, shorter timeframes

Changes in Medical Education – "The Old Model"

Longitudinal Professional Development

Basic Science (M1)

Clinical Science (M2)

Abundance of science but little-to-no clinical exposure/patient contact

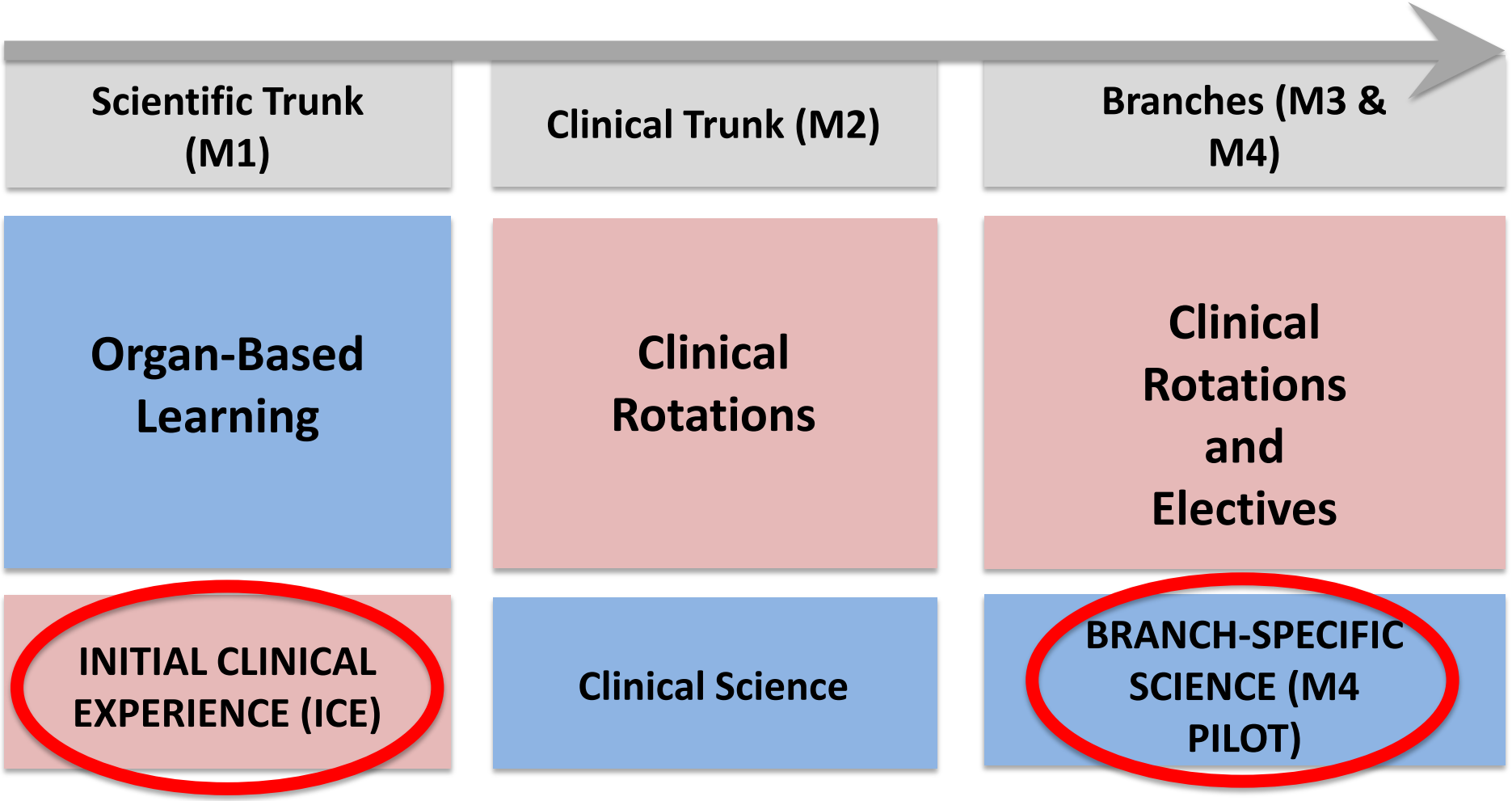
Clinical Rotations (M3)

Clinical Rotations and Electives (M4)

Abundance of clinical exposure but little-to-no continued science education

Adapted from: http://curriculum.med.umich.edu/faqs

Changes in Medical Education – The "New" Model



Adapted from: https://medicine.umich.edu/medschool/education/md-program/curriculum/diagrams

Scheduling Challenges

- Assigning M1's to clinics (ICE)
- Ensuring M4's continue their science education while having the freedom to choose elective rotations (M4 Pilot)

The ICE Program

- Assigns 168 M1's to clinics in which they shadow healthcare professionals subject to certain rules:

1. Every student must be assigned to exactly one clinic
2. Every clinic must have at least one student assigned to it
3. Every clinic has a maximum number of students it can take

The ICE Program cont.

- Assigns 168 M1's to clinics in which they shadow healthcare professionals subject to certain rules:

4. If a student was assigned to an inpatient clinic previously, he or she must be assigned to an outpatient clinic (and vice versa)
5. Only students with cars can be assigned to off-site clinics
6. Students enrolled in Medical Spanish must be assigned to on-site clinics
7. Each student lists their two **least** desired clinics

ICE Model Formulation - Constraints

1.) Student Coverage Requirements

Every student *s* must be assigned to exactly one *open* clinic

$$\sum_{c \in C} x_{sc} = l_c, \quad \forall s \in S$$

2.) Clinic Capacity Requirements

The number of students assigned to clinic *c* must be at least 1 if open and not exceed clinic capacity u_c

$$l_c \leq \sum_{s \in S} x_{sc} \leq u_c, \quad \forall c \in C$$

ICE Model Formulation - Constraints

3.) Inpatient-Outpatient Clinical Experience Requirements

Every student *s* should fulfill one inpatient clinical experience and one outpatient clinical experience

$$\sum_{c \in C_O} a_s x_{sc} + \sum_{c \in C_I} b_s x_{sc} = 1 - v_s^i - v_s^o, \quad \forall s \in S$$

4.) Student Car Requirements

Only students with cars should be assigned to offsite clinics

$$\sum_{c \in C_R} x_{sc} = z_s + v_s^c, \quad \forall s \in S$$

5.) Medical Spanish Requirements

Students registered for Medical Spanish should be assigned to onsite clinics

$$\sum_{c \in C_P} x_{sc} = 1 - v_s^m, \quad \forall s \in S_M$$

ICE Model Formulation - Objective

Objective Function:

$$\min \quad \sum_{s \in S} \sum_{c \in C} v_{sc} x_{sc}$$

Assignments to least-preferred clinics

$$+ \quad c_1 \sum_{s \in S} [v_s^i + v_s^o]$$

Inpatient-Outpatient violations

$$+ \quad c_2 \sum_{s \in S} v_s^c$$

Car Violations

$$+ \quad c_3 \sum_{s \in S_M} v_s^m$$

Medical Spanish Violations

Revised Model Implementation

- Implemented in Open Solver
- Run time < 15 seconds
- Outputs number of violations of each type
- Worked with program directors to fine-tune assignments
- Adjusted weights in accordance with their desires
- Two semesters scheduled so far
- Plans to add functionality going forward

The M4 Pilot Program

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Procedures	Systems	P & P	Diag. Ther. Tech
Diabetes (Pathophysiology/Treatment)	**Diabetes** (Pathophysiology/Treatment)	**Diabetes** (Pathophysiology/Treatment)	**Trauma** (Biomechanics/Mechanism of injury)
Sepsis (Pathophysiology/Treatment)	**Sepsis** (Pathophysiology/Treatment)	**Diabetes** (Prevention/Population Mgmt./Genetics)	**Cancer** (Pathology/Diagnosis/Imaging)
Cancer (Pathophysiology/Treatment)	**Cancer** (Pathophysiology/Treatment)	**Cancer** (Prevention/Population Mgmt./Genetics)	**Cancer** (Pathophysiology/Treatment)
Trauma (Biomechanics/Mechanism of injury)	**Cardiovascular** (Pathophysiology/Treatment)	**Cardiovascular** (Prevention/Population Mgmt./Genetics)	**Cardiovascular** (Pathophysiology/Diagnosis/ Imaging)

The M4 Pilot Program cont.

- Assigns M4's to student groups working on a specific science activity in a specific month subject to:

1. Each student must complete three out of four science activities associated with their branch
2. Students can only complete science activities based on cases that were seen during that particular rotation
3. Each group may have 3-5 students from any branch, but groups of 4 are strongly preferred

The M4 Pilot Program cont.

- Assigns M4's to student groups working on a specific science activity in a specific month subject to:

4. Students specify their least desired science activity for their branch
5. Students can only participate in science activities within their branch requirements
6. Students can only participate in one science activity per month
7. Students cannot participate in the same science activity twice

M4 Pilot Program Model - Constraints

1.) Group Size Requirements

Each student group must contain at least 3 and at most 5 students

$$3y_{am} \leq \sum_{s \in S} x_{sam} \leq 5y_{am}, \quad \forall a \in A, m \in M$$

2.) Group Size Preference

Each student group should contain four students plus or minus any groups of five or groups of three, respectively

$$\sum_{s \in S} x_{sam} = 4y_{am} + (n^{+}_{am} - n^{-}_{am}), \quad \forall a \in A, m \in M$$

3.) Science Activity Completion Requirements

Each student must complete exactly three of four approved science activities within their branch requirements

$$\sum_{a \in A} \sum_{m \in M} a_{sa} x_{sam} = 3, \quad \forall s \in S$$

M4 Pilot Program Model - Constraints

4.) Preventing Unapproved Assignments

Students cannot be assigned to science activities not within their branch requirements

$$\sum_{a \in A} \sum_{m \in M} (1 - a_{sa}) x_{sam} = 0, \quad \forall s \in S$$

5.) Activity Eligibility Requirements

Students can only complete a science activity in month *m* that is seen in the clinical rotation they select for that month.

$$x_{sam} \leq e_{sam}, \quad \forall s \in S, a \in A, m \in M$$

6.) Prevention of Duplicate Assignments

Students cannot be assigned to a particular science activity more than once

$$\sum_{m \in M} a_{sa} x_{sam} \leq 1, \quad \forall s \in S, a \in A$$

7.) Maximum Number of Science Activities per Period

Students cannot be assigned to more than one science activity per month

$$\sum_{a \in A} x_{sam} \leq 1, \quad \forall s \in S, m \in M$$

M4 Pilot Program Model - Objective

Objective Function:

$$\min \quad c_1 \sum_{s \in S} \sum_{a \in A} \sum_{m \in M} u_{sa} x_{sam}$$

Assignments to undesired activities

$$+ \quad c_2 \sum_{a \in A} \sum_{m \in M} n^{+}_{am}$$

Number of groups containing 5 students

$$+ \quad c_3 \sum_{a \in A} \sum_{m \in M} n^{-}_{am}$$

Number of groups containing 3 students

Conclusion and Future Work

- Large impact from simple, straight-forward problems
- Program administrator workload reduction
- Higher medical student satisfaction
- Undergraduate-led project teams
- Long-term collaboration with the medical school

Acknowledgements

Seth Bonder Foundation

University of Michigan Medical School

Questions / Comments

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