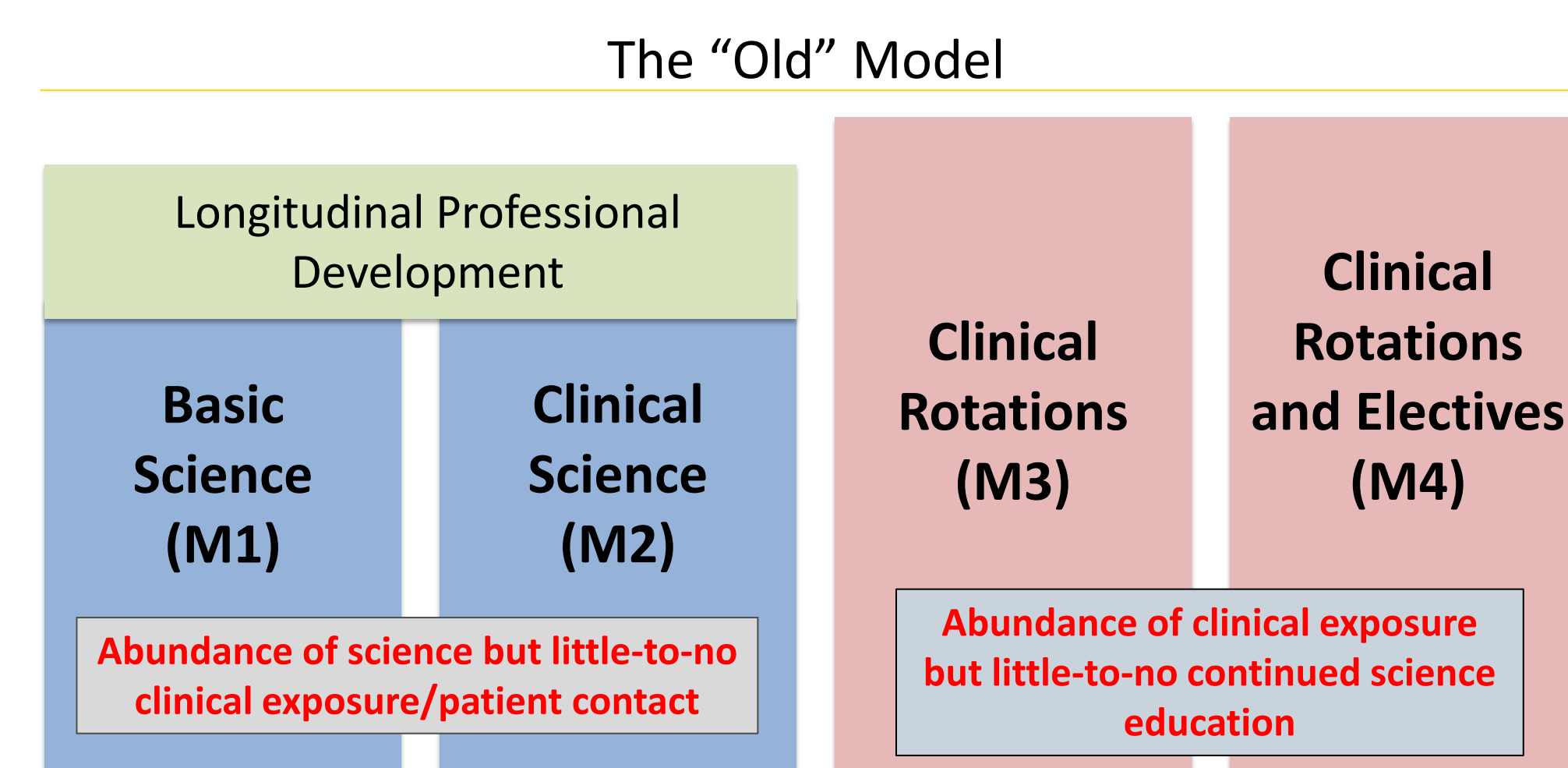


Initial Clinical Experience (ICE)

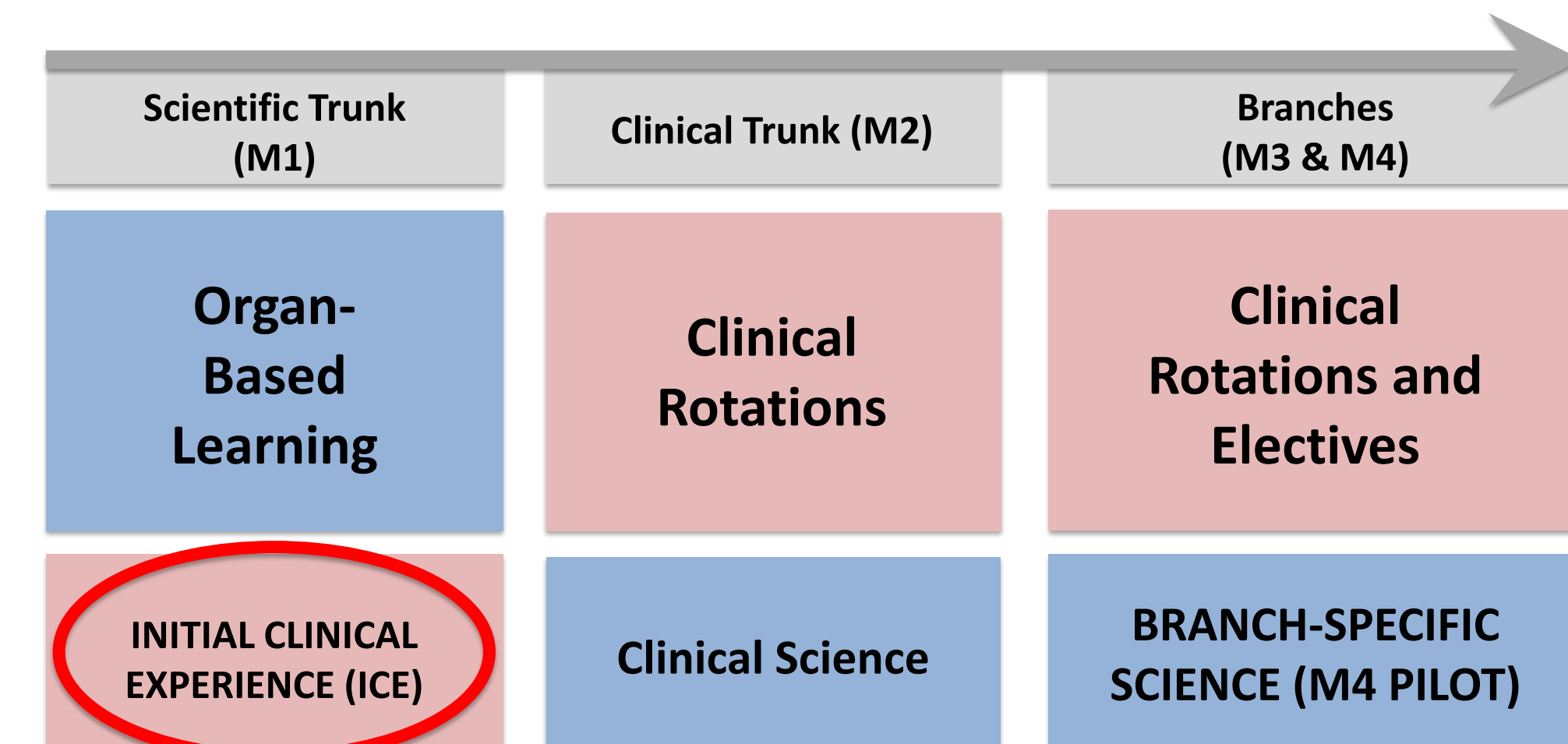
Background

New medical school curricula replace the traditional 2+2 format with continued science education and clinical exposure throughout medical school



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

The "New" Model



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

Problem Statement

ICE schedules must assign 168 first-year medical students (M1s) to clinics in which they shadow healthcare professionals, subject to numerous rules

Model

Decision Variables

x_{sc}	1 if student s is assigned to clinic c	$\forall s \in S, c \in C$
v_s^i	1 if student s is assigned to two inpatient clinics	$\forall s \in S, c \in C$
v_s^o	1 if student s is assigned to two outpatient clinics	$\forall s \in S, c \in C$
v_s^c	1 if student s violates the student car requirement	$\forall s \in S$
v_s^m	1 if student s violates the Medical-Spanish requirement	$\forall s \in S_M$

Objective Function

$$\min \sum_{s \in S} \sum_{c \in C} v_{sc} x_{sc} \quad \left. \begin{array}{l} \\ \\ \\ \end{array} \right\} \begin{array}{l} \text{Assignments to least-preferred clinics} \\ \text{Inpatient-Outpatient violations} \\ \text{Car Violations} \\ \text{Medical Spanish Violations} \end{array}$$

Solution Approach

We formulated a linear programming model and implemented in a Microsoft Excel workbook, using the OpenSolver add-in

Sample Inputs

Last	First	Doctoring Group	Vehicle?
Doe	John	A-Fitzbutler: 1.1	No
Gupta	Sandeep	A-Fitzbutler: 2.1	Yes
Johnson	David	A-Fitzbutler: 3.1	Yes
Lee	Michael	A-Fitzbutler: 1.1	No
Smith	Carson	A-Fitzbutler: 4.1	Yes
Waidley	Victoria	A-Fitzbutler: 4.2	Yes

Clinics	Emerg. Med.	Hosp. A	Hosp. B	PM&R-Inpt.	EAA, MP
Tuesday 1 (Fitzbutler)	6	8	0	6	3
Tuesday 2 (Salk)	6	8	0	6	3
Thursday 1 (Hamilton)	6	0	8	6	3
Thursday 2 (Sanford)	6	0	8	6	3
Onsite Location?	Yes	Yes	Yes	Yes	Yes

Sample Output

Name	Subgroup	Emerg. Med.	Hosp. A	Hosp. B	PM&R-Inpt.	EAA, MP
Doe, John	A-Fitzbutler: 1.1	0	0	1	0	0
Gupta, Sandeep	A-Fitzbutler: 2.1	0	0	0	0	1
Johnson, David	A-Fitzbutler: 3.1	0	0	0	1	0
Lee, Michael	A-Fitzbutler: 1.1	0	0	0	1	0
Smith, Carson	A-Fitzbutler: 4.1	0	0	1	0	0
Waidley, Victoria	A-Fitzbutler: 4.2	0	0	1	0	0

Sample Final Schedule

House A - Fitzbutler		Rotation 1	Rotation 2	Rotation 3	
Name	Subgroup	Site Fall	September 1	September 15	October 13
Doe, John	A-Fitzbutler: 1.1	Hosp. B	PT/OT, UH	Phys, UH South	Pharm, Mott
Gupta, Sandeep	A-Fitzbutler: 2.1	EAA, MP	Pharmacist	Nurse	Physician
Johnson, David	A-Fitzbutler: 3.1	PM&R-Inpt	Physician	Nurse	Rec Therapy
Lee, Michael	A-Fitzbutler: 1.1	PM&R-Inpt	Nurse	OT	Social Work
Smith, Carson	A-Fitzbutler: 4.1	Hosp. B	Phys, UH South	Pharm, Mott	Neonatal NP
Waidley, Victoria	A-Fitzbutler: 4.2	Hosp. B	Nursing, 12 West	PT/OT, UH	Phys, UH South

Impact/Results

- Generated full schedules rapidly (solve time < 15 seconds)
- Collaborated with program directors to fine-tune assignments
- Applied tool to schedule four semesters to date
- Output number of rule violations for directors' review
- Reduced program administrator burden
- Improved medical student satisfaction
- Derived high impact from mathematically simple, straight-forward modeling with undergraduate-led project team
- Fostered long-term collaboration with medical school

Pediatric Inpatient Night Team

Background

Night teams in the Pediatric inpatient units are composed of residents and interns from the Pediatrics, Medicine-Pediatrics, and Emergency Medicine programs

Three senior residents and three interns are assigned to the night team at any time

Night team schedules are subject to a number of restrictions that aim to balance residents' clinical and educational responsibilities and differ by residency program

Problem Statement

Night Team schedules must effectively balance residents' competing responsibilities and ensure adequate coverage of the Pediatric Emergency Department

Model

Decision Variables

x_{rad}	1 if resident r is assigned to activity a on date d	$\forall r \in R, a \in A, d \in D$
y_{rd}	1 if resident r is assigned to attend conference on date d	$\forall r \in R, d \in D$

Constraints

- One activity per resident per day
$$\sum_{a \in A} x_{rad} = 1, \quad \forall r \in R, d \in D$$
- Every activity must be adequately covered each day
$$LB_{ad} \leq \sum_{r \in R} x_{rad} \leq UB_{ad}, \quad \forall a \in A, d \in D$$
- No resident can work fewer than two consecutive nights in any work sequence
$$x_{rad} \leq x_{ra(d-1)} + x_{ra(d+1)}, \quad \forall r \in R, d \in \{2, \dots, |D| - 1\}$$

$$x_{ra(1)} \leq x_{ra(2)}, \quad \forall r \in R$$

$$x_{ra(|D|-1)} \leq x_{ra(|D|-2)}, \quad \forall r \in R$$
- No resident can work more than six consecutive nights in any work sequence
$$\sum_{d=d'}^{d'+M^a} x_{rad} \leq M^a, \quad \forall r \in R, a \in A, d' \in \{1, \dots, |D| - M^a\}$$
- Emergency Medicine residents must attend at least one of their conferences during rotation
$$\sum_{d \in D} y_{rd} \geq 1, \quad \forall r \in \{\text{Emergency Medicine}\}$$

$$y_{rd} \leq x_{r(\text{day off})d}, \quad \forall r \in R, d \in D$$

$$y_{rd} \leq x_{r(\text{day off})(d-1)}, \quad \forall r \in R, d \in \{2, \dots, |D|\}$$
- Emergency Medicine residents must attend at least one of their conferences during rotation
$$LB_{ra} \leq \sum_{d \in D} x_{rad} \leq UB_{ra}, \quad \forall r \in R, a \in A$$

Solution Approach

We formulated a linear programming model and implemented in a Microsoft Excel workbook, using the OpenSolver add-in

Sample Inputs

Resident	Program	Level	Start Date	End Date	Shifts LB	Shifts UB
Jayasundera	MP	Intern	02/27/2017	03/12/2017	9	11
White	PEDS	Intern	02/27/2017	03/12/2017	9	11
Herman	EM	Intern	03/01/2017	03/15/2017	9	11
Baughman	PEDS	Senior	03/01/2017	03/15/2017	9	11
Lemke	PEDS	Senior	03/02/2017	03/15/2017	9	11
Lam	PEDS	Senior	03/01/2017	03/15/2017	9	11

	02/27/2017	02/28/2017	03/01/2017	03/02/2017	03/03/2017	03/04/2017
	Mon	Tue	Wed	Thu	Fri	Sat
Intern LB	1	2	2	2	2	2
Intern UB	2	2	2	2	2	2
Senior LB	0	0	2	2	2	2
Senior UB	0	0	2	2	2	2

Sample Output

Resident	02/27/2017	02/28/2017	03/01/2017	03/02/2017	03/03/2017	03/04/2017
	Mon	Tue	Wed	Thu	Fri	Sat
Jayasundera	Night Team	Night Team	Night Team	Day Off	Day Off	Night Team
White	Day Off	Night Team	Night Team	Night Team	Night Team	Day Off
Herman	Day Off	Day Off	Conference	Night Team	Night Team	Night Team
Baughman	Day Off	Day Off	Night Team	Night Team	Night Team	Day Off
Lemke	Day Off	Day Off	Day Off	Day Off	Day Off	Night Team
Lam	Day Off	Day Off	Night Team	Night Team	Night Team	Night Team

Impact/Results

- Generated full schedules rapidly (solve time < 5 seconds)
- Reduced chief resident burden from approximately 6 hours per month to half hour
- Automated scheduling to more effectively balance resident responsibilities
- Improved compliance with resident day-off requests
- Completed by undergraduate-led project teams
- Provided quick, impactful outcomes that strengthened relationships with Michigan Medicine residency programs

Acknowledgments

We thank the following organizations for funding this work:



Special thanks to Joseph House, MD, Angie Sullivan, Jonathan Mogannam, Emily Snitchler, Henry Ballout, and Joseph Porcari for their work in developing this tool.