Reaching the Community with Mathematical Biology

Olgamary Rivera-Marrero
oriveram@math.vt.edu

Brandilyn Stigler
bstigler@vbi.vt.edu

Purpose

To develop and implement a mathematics workshop for secondary mathematics teachers and high school students.

The workshop was designed to introduce mathematical biology and to demonstrate innovative ways of teaching mathematics with graphical modeling software.

Focus and Topics of the Workshop

Students

- Learn how to apply basic mathematical concepts to model real-world situations.

Teachers

- Acquire new ideas of integrating non-standard mathematics into the classroom.

Abstract Algebra

- Abstract structures: inverses and identities
- Properties of operations: commutative, associative, distributive
- Finite fields: arithmetic and functions
- **Software:** *Discrete Visualizer of Dynamics* (DVD)

Graph Theory

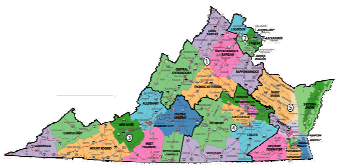
- Graphs: vertex , weighted
- Adjacency matrices
- Vertex coloring
- Paths and cycles: shortest, eulerian, hamiltonian
- **Software:** *Mathematical Modeling: Using Graphs/Matrices* (MM)

All participants applied these concepts to an epidemiological problem.

Viral Epidemic Project

Given data of the number of cases of influenza

- Find a model to predict a possible future epidemic.
- Find a model to prevent the spread of the infection.



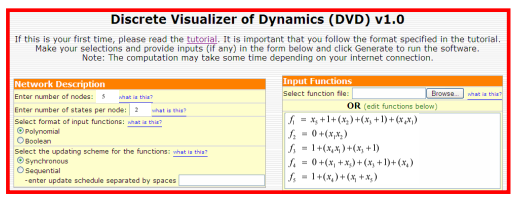
	NW	N	SW	C	E
1996	124	2	579	9	243
1997	116	22	310	1	68
1998	181	34	758	33	154
1999	407	132	1603	102	314
2000	337	110	1120	50	292
2001	362	141	903	161	396
2002	795	345	887	534	925
2003	3017	1791	4789	3599	5451

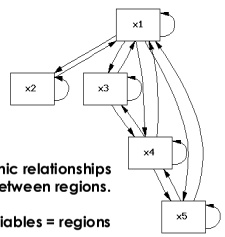
Table 1: 1996 - 2003 Reported Flu Cases in Virginia regions: NW(1) = Northwest, N(2) = North, SW(3) = Southwest, C(4) = Central, E(5) = Eastern.

The teachers generated ideas to integrate standard mathematics and the topics of the workshop through interactions with the students and the other teachers.

Solutions

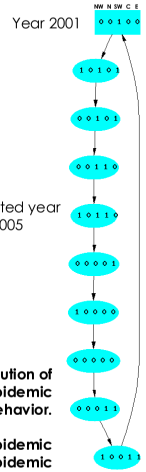
One possible model of prediction





Graph 1: Geographic relationships between regions.

Variables = regions



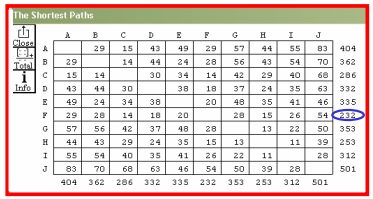
Graph 2: Evolution of flu epidemic behavior.

0 = no epidemic
1 = epidemic

This implies that the regions NW, SW, and C are likely to experience influenza at epidemic levels in the 2005/2006 flu season.

One possible model of prevention (one county in SW)

A clinic will be constructed in the most central locality in the identified county.



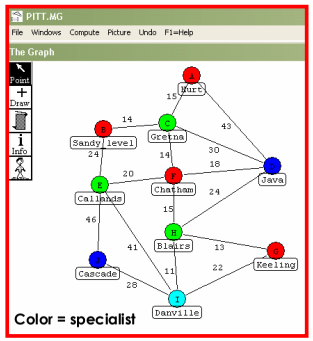
	A	B	C	D	E	F	G	H	I	J	
A		29	15	43	49	29	57	44	55	83	404
B	29		14	44	24	28	56	43	54	70	362
C	15	14		30	34	14	42	29	40	68	286
D	43	44	30		38	18	37	24	35	63	332
E	49	24	34	38		20	48	35	41	46	335
F	29	28	14	18	20		28	15	26	54	232
G	57	56	42	37	48	28		13	22	50	353
H	44	43	29	24	35	15	13		11	39	253
I	55	54	40	35	41	26	22	11		28	312
J	83	70	68	63	46	54	50	39	28		501
	404	362	286	332	335	232	353	253	312	501	

Chatham is most central.

Table 2: Shortest-path matrix for driving times between cities in the county.

Letter = city
Number = shortest driving time

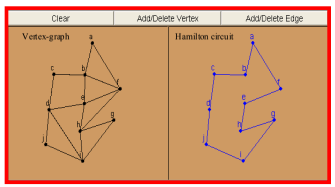
Dissemination of information by health specialists is one way to prevent spread of the flu.



Color = specialist

Graph 3: Vertex coloring of weighted graph for the county.

The minimum number of specialists needed are 3.



Graph 4: Hamiltonian circuit for one possible route for the specialists to visit each city in the county. The route starts and ends at the clinic.

Conclusions

- The students extended their problem solving and communication skills.
- The teachers explored ways to incorporate the concepts into their own classrooms.
- All participants established a connection among mathematics, biology, modeling, and technology.

References

- DVD: http://dvd.vbi.vt.edu
- MM: http://www.learninginmotion.com
- National Council for Teachers of Mathematics: http://www.nctm.org
- Graph theory lessons: http://www.utc.edu/Faculty/Christopher-Mawata/petersen/lesson12b.htm