An Introductory Mathematical Modeling Course without Calculus

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VMI: 2006 – 2018

- VMI has Core Curriculum, requiring 6 hrs of math from a 2-course sequence
- Three sequences:
  - Calculus I & II
  - Probability and Statistics I & II
  - Quantitative Methods I & II
- SACSCOC Quality Enhancement Plan: revamp the latter two sequences

VMI: 2006 – 2018

QEP Mission:
Improve student learning in non-STEM core curriculum math courses by

- collaborating with faculty in non-STEM departments to develop discipline- specific, contextualized math problems,
- helping non-STEM students to be computationally confident problem-solvers, and
- designing and implementing instruction that is contemporary, evidence-based (e.g., authentic/inquiry learning), and incorporates academic motivation strategies designed to enhance perceptions of interest and usefulness.

VMI: 2006 – 2018

- Course sequence is developed, titled "Math That Matters."
- Content determined in consultation with served departments
- First taught Summer / Fall 2018.

Course Theme

- All newly-developed courses undergo revision: content is added, removed, rewritten.
- A theme emerged: mathematical modeling.
- Over time, we leaned into learning Excel.

Course Theme

- No 2nd Semester Final Exam, but Final Project
  - Pairs pick topic, question, develop answer, report
  - Wide variety of questions, though three common categories:
    - Fit data with trendline, make future prediction
    - Determine "the best of" within a category
    - Compare statistics of groups, conduct hyp. test
- All of Math That Matters should support a Final Project
- The Final Project is cumulative, culminating.

Semester 1 Content

- Unit 1 – Excel and Basic Modeling
  - Introduction to Excel - The Cultural Trip
  - Basic Mathematical Models: Linear, Exponential, Polynomial Trendlines

Semester 1 Content

- Unit 2 – Descriptive Statistics
  - The Shape of Data (Pivot Tables/Charts)
  - Measures of Center – Mean, Median
  - Measures of Spread – IQR, Standard Deviation
  - Measures of Relative Standing

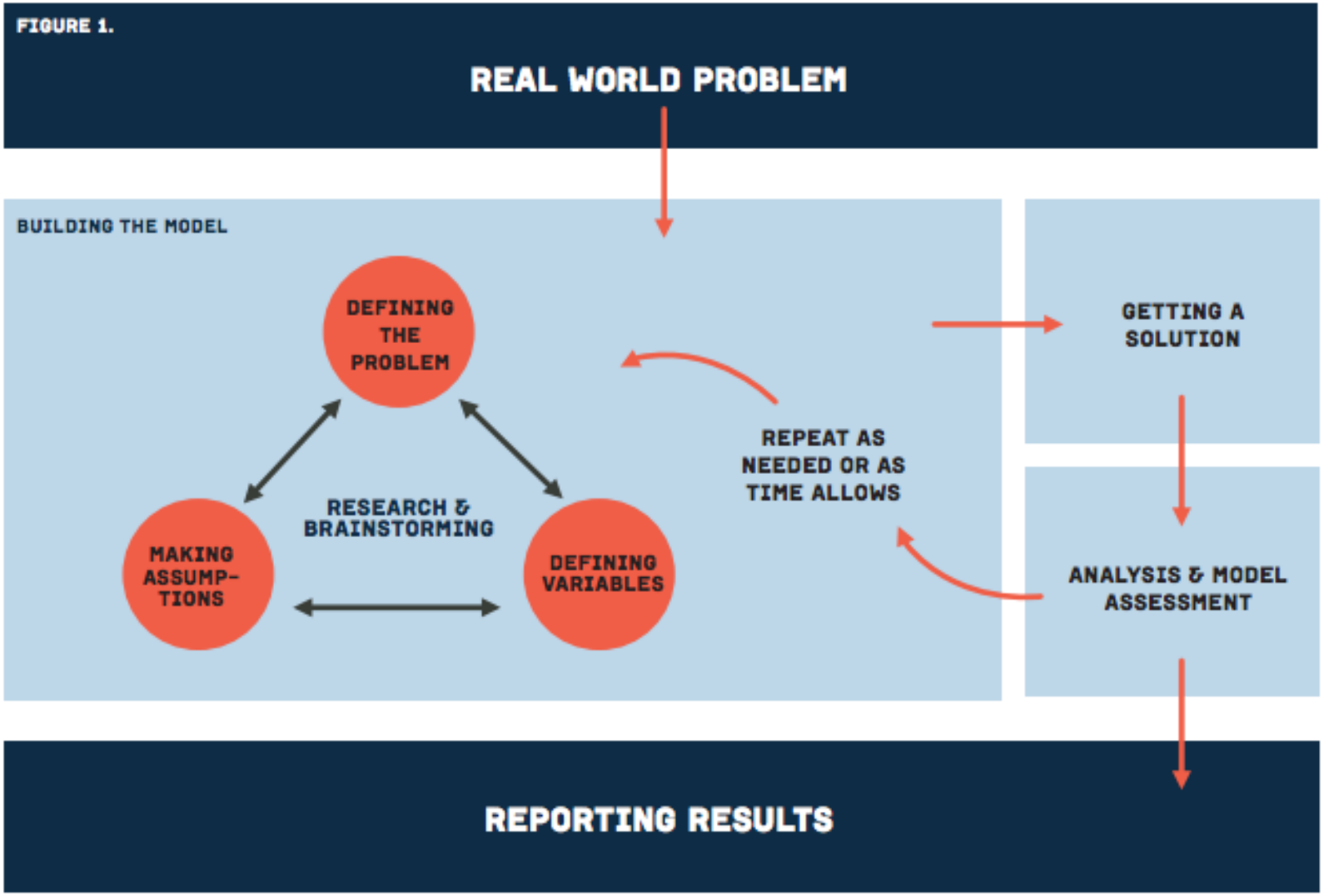
Semester 1 Content

- Unit 3 – Inferential Statistics
  - Confidence Intervals (means, proportions)
  - Hypothesis Testing (1-,2-sample, means, proportions, dependence)
  - Pre-made tools on Excel are used to compute errors, intervals, p-values

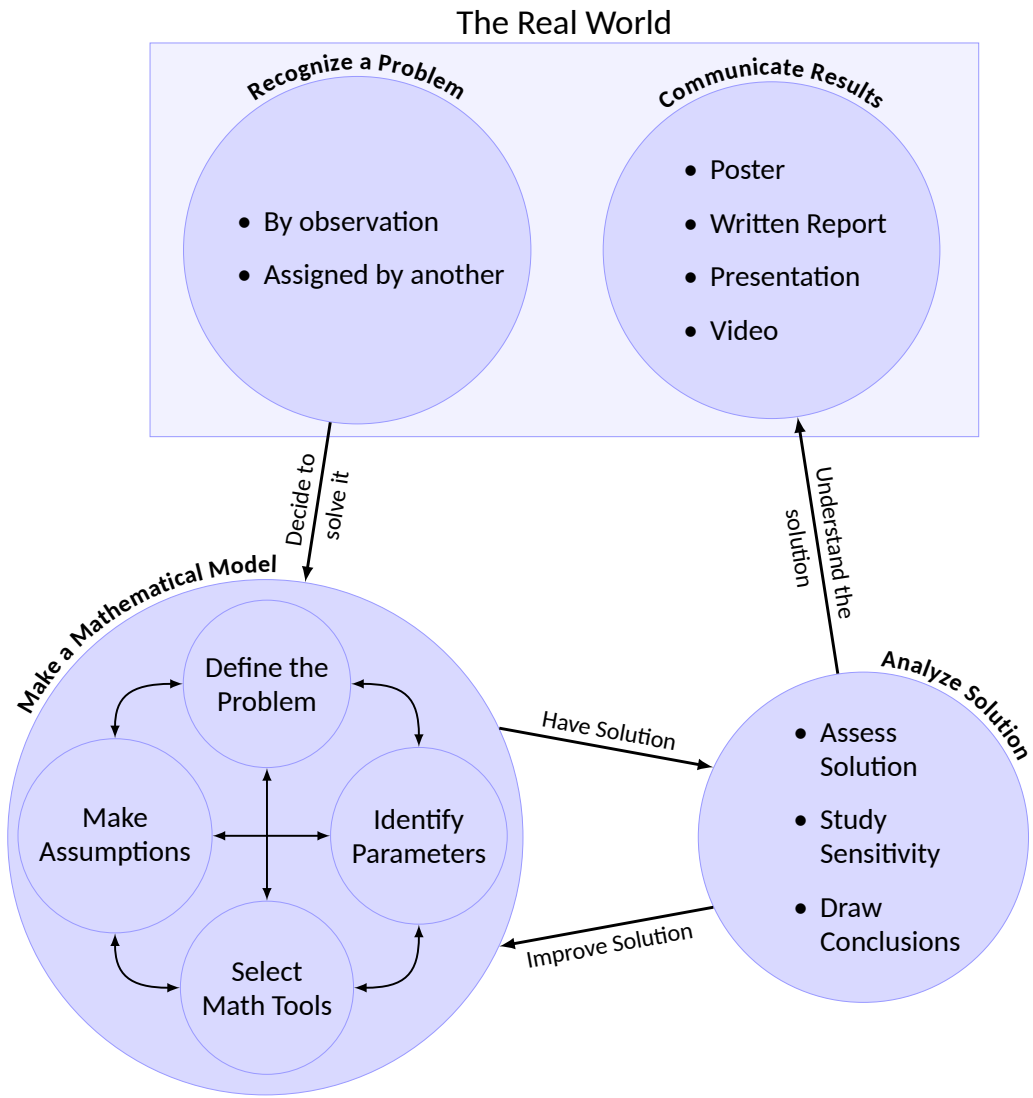
Semester 2 Content

- Unit 1 - Modeling
  - Formally recognize modeling as a process, consider the steps.
  - "A model shows you what the real thing will be without having the real thing."
  - Projects:
    - The Mona Lisa on a Wall
    - The Art of Albrecht Dürer
    - Planning Graduation

Semester 2 Content



Semester 2 Content



Semester 2 Content

- Unit 2 - Metrics
  - How to quantify the qualitative
  - Create metric to measure "cadet quality"
  - Project: The Good Cadet
    Design a study to see if an activity improves your measure of yourself
    - What are you optimizing?
    - Testable question?
    - What data do you need to collect, how can you reliably get that data, and what permissions do you need to use that data?

Semester 2 Content

- Unit 3 - Sensitivity Analysis
  - You made a plan, then things change. How much will your outcome change?
  - Context: basic financial mathematics (pay off loan, save for retirement)
  - Project: Army Finance
    Commission into the Army, make plan to save $30K in TSP by the time you could reach Captain, then resign commission.
    - How sensitive is your $30K goal to changes in APR? Personal contribution?
    - Money grows by interest until retirement. How sensitive is final amount to the above?

Semester 2 Content

- Unit 4 - Communicating Results
  - "The best ideas are worthless if you can't communicate them well to decision makers."
  - Context: Netlogo simulation of virus spread (SIR model)
  - Project: Spreading Viruses
    Write report to authority (college president, mayor, governor, etc.) that describes outcomes under
    - a "do nothing" policy,
    - a highly restrictive policy, and
    - a middle-ground policy.

Assessment

Anecdotal / Focus Groups:

- Excel is a win
- Final project & other group work is rewarding
- "This class has great applications for other majors."
- Student and faculty expectations on assignments
  - More writing, few numbers to circle.
    (How to write? What to write? How to grade?)
  - Making instructions clear / actually reading instructions.
- "Excel that matters."

Survey Results

Statement	Post - Pre*	p
I am able to solve mathematics problems without too much difficulty.	0.32	0.017
I am comfortable expressing my own ideas on how to look for solutions to a difficult problem in math.	0.30	0.008
Mathematics is dull and boring.	0.34	0.008

*: Difference in pre/post semester survey averages, 5-pt Likert scale, $n \sim 150$

Assessment

Survey Results

Statement	Result*
"I feel confident that I can use Excel to solve math problems."	93%, 4.9, (1.02)
"I feel confident that I can use computers to solve math problems"	93%, 4.8, (1.05)
"I enjoy using a computer when learning mathematics."	81%, 4.6, (1.26)
"Technology can make mathematics easier to understand."	90%, 4.8, (1.16)

*: % Agree, 6-pt Likert scale mean, (std. dev.); $n = 88$

Thanks / Questions

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