GAIMME

GUIDELINES FOR ASSESSMENT & INSTRUCTION IN MATHEMATICAL MODELING EDUCATION

CONSORTIUM FOR MATHEMATICS AND ITS APPLICATIONS (COMAP)

SOCIETY FOR INDUSTRIAL AND APPLIED MATHEMATICS (SIAM)

IMPLEMENT THE MODEL

For real world, practical applications, we report our results to others and implement the solution.

Mathematical modeling is often pictured as a cycle, since we frequently need to come back to the beginning and make new assumptions to get closer to a useable result. However, we will use the representation below as it reflects the fact that in practice a modeler often bounces back and forth through the various stages:

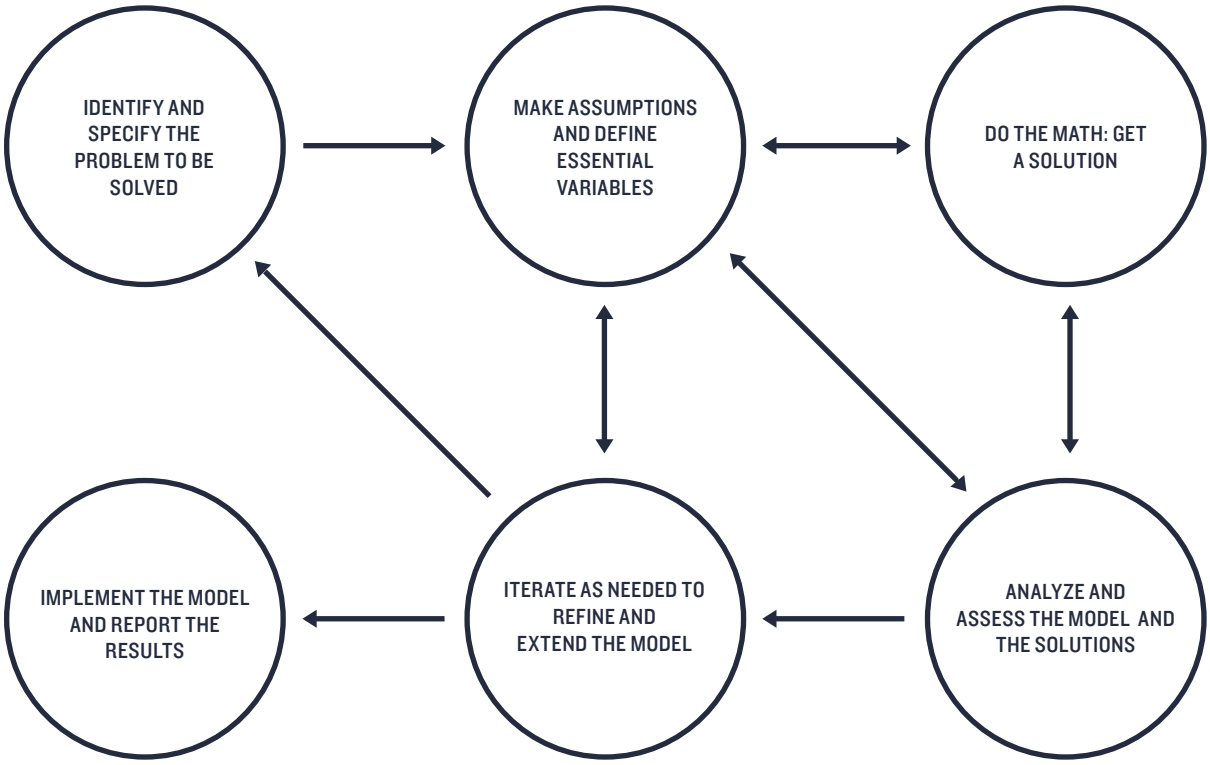

FIGURE I.2: THE MATH MODELING PROCESS

Note that as shown in the figure, the modeling process contains cyclical components and that not all arrows are unidirectional. As such we have intentionally not used the term 'steps' nor have we numbered the components of the modeling process. We do not wish to imply that there exists an ordered number of steps that we could follow to guarantee that we have found a solution to a modeling problem. On the contrary some components happen in parallel and some are repeated as needed. We will see some of this nuance in the examples below and others are highlighted in the examples in the Appendices.

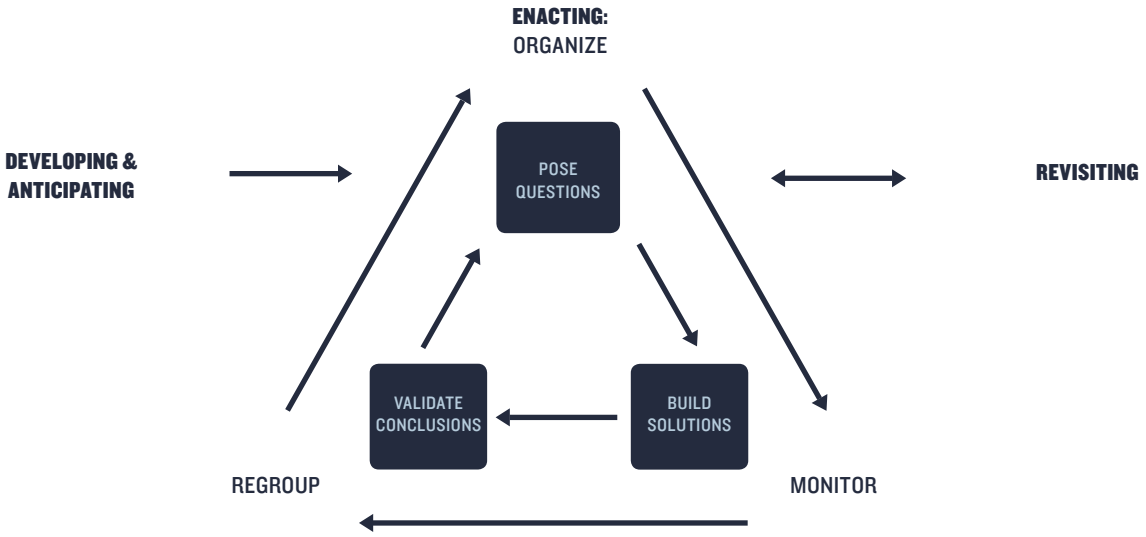

FIGURE 2.3: FRAMEWORK FOR TEACHERS' ROLES IN FACILITATING MODELING, ADAPTED WITH PERMISSION FROM CARLSON ET AL. (2016).

developing a new problem or adapting a modeling problem that someone else created, the following questions can help guide your choices.

IS THIS PROBLEM REALLY A MODELING PROBLEM, AND HOW CAN I LAUNCH THE PROBLEM SUCH THAT IT IS MESSY AND OPEN-ENDED?

As we noted in Chapter 1, simply adding labels or context does not make a problem a good modeling problem. A modeling problem should also involve student decision-making that shapes the problem definition, modeling processes and variety of the solutions.

WHAT MATHEMATICAL CONTENT DO I WANT TO ADDRESS IN THIS MODELING PROBLEM, AND DOES THIS PROBLEM ADDRESS THAT CONTENT?

Whether the modeling activity promotes curiosity and discovery in a new topic, provides an opportunity to put a recently acquired skill into practice, or to draws connections and revisits previously presented content, if you want the modeling process to lead towards specific mathematical content, you will want to develop the problem and/or facilitation with these learning objectives in mind. As shown in Chapter 1, modeling problems can be developed by adding flexibility and room for creativity to existing book problems. Appendix B offers two additional examples of modeling problems, both designed to target the specific modeling topic of division, although the two problems have different levels of open-endedness. The Buses and Quotients problem opens a door to modeling only by

MODELING COMPONENT	QUESTIONS ABOUT YOUR MODEL AND HOW YOU MADE IT	MODELING-RELATED VOCABULARY TO BUILD
DEFINING THE PROBLEM	What is the big problem that you have been asked to solve? It might have more than one possible answer.	open-ended problem, constraints
DEFINING THE PROBLEM	What is the specific problem your model is going to solve? (My model will tell you...)	specific, focus
MAKING ASSUMPTIONS	What ideas did you think about that you decided not to try?	eliminate, prioritize
MAKING ASSUMPTIONS	What have you assumed in order to solve the problem? Why did you make these choices?	assumption/assumed
DEFINING VARIABLES	What quantities are important? Which ones change and which ones stay the same?	variable
DEFINING VARIABLES	Where did you find the numbers that you used in your model?	resources, citations
GETTING A SOLUTION	What pictures, diagrams or graphs might help people understand your information, model, and results?	diagram, graph, labels
GETTING A SOLUTION	What mathematical ideas did you use to describe the situation and solve your problem?	situation
ANALYSIS AND MODEL ASSESSMENT	How do you know that your calculations are correct? Did you remember to use units (like dollars or inches?)	calculation, unit
ANALYSIS AND MODEL ASSESSMENT	When does your model work? When do you need to be careful because it might not?	limitations
ANALYSIS AND MODEL ASSESSMENT	How do you know you have a good/useful model? Why does your model make sense?	testing, validation
ANALYSIS AND MODEL ASSESSMENT	If you were going to make your model better, what would you do?	improvement, iteration
REPORTING RESULTS	Explain your mathematical model in words and math.	testing, validation
REPORTING RESULTS	How did each of your teammates help?	model
REPORTING RESULTS	What did you learn from each other member of your team?	collaborate
REPORTING RESULTS	What are the 5 most important things for your audience/client to understand about your model and/or solution?	client, audience

TABLE D.I: MODELING ASSESSMENT RUBRIC (ADAPTED FROM LEVY, IMMERSION).

DEFINE THE MODELING PROBLEM (3 POINTS TOTAL)			
IDEAL	**SATISFACTORY**	**NEEDS IMPROVEMENT**	**INCOMPLETE**
(3 points) Concise problem statement that indicates exactly what the output of the model will be and, if appropriate, identifies the audience and/or perspective of the modeler. Statement is presented early in the paper.	(2 points) Problem statement is easily identifiable but not precise or consistent with other statements in paper.	(I point) Problem statement is difficult to understand or is buried in the text.	(0 points) No problem statement is given.

BUILDING THE MODEL: MAKE ASSUMPTIONS AND ACKNOWLEDGE LIMITATIONS (3 POINTS TOTAL)			
IDEAL	**SATISFACTORY**	**NEEDS IMPROVEMENT**	**INCOMPLETE**
(3 points) Primary assumptions used to develop the model are clearly identified, easy-to-read and well justified. Limitations due to simplification are stated when appropriate.	(2 points) Primary assumptions are noted; justification or readability is lacking.	(I point) Assumptions and justification exist, but are difficult to identify in the text.	(0 points) No assumptions –or justification for lack of assumptions is provided.

BUILDING THE MODEL: DEFINE VARIABLES AND IDENTIFY PARAMETER (3 POINTS TOTAL)			
IDEAL	**SATISFACTORY**	**NEEDS IMPROVEMENT**	**INCOMPLETE**
(3 points) Notes and rationalizes the need for the primary factors that influence the phenomena being modeled in a readable format; proper units are specified.	(2 points) Important parameters and variables are listed properly but without sufficient explanation.	(I point) Variables/parameters are wither barely mentioned or hard for the reader to identify in the text.	(0 points) No variables or parameters are identified.

SOLUTION: MODEL USES MEANINGFUL MATHEMATICS (4 POINTS TOTAL)			
IDEAL	**SATISFACTORY**	**NEEDS IMPROVEMENT**	**INCOMPLETE**
(4 points) Provides a readable glimpse into the mathematical method(s) used to solve the problem. Plausible approach and outcome is presented.	(3 or 2 points) Mathematical approach is stated, but aspects of the method(s) are inconsistent, difficult to understand or incomplete.	(I point) Model is stated and/or contains fixable mathematical errors.	(0 points) Model is not presented or contains significant errors.

SOLUTION: RESULTS ARE ACCESSIBLE TO THE AUDIENCE (4 POINTS TOTAL)			
IDEAL	**SATISFACTORY**	**NEEDS IMPROVEMENT**	**INCOMPLETE**
(4 points) Clearly presents a solution that is consistent with the original problem statement. If appropriate, a useful visual aid/graphic is included.	(3 or 2 points) Answer is stated, but aspects of the solution(s) are inconsistent, difficult to understand or incomplete (e.g. fail to identify units of measure).	(I point) Answer is given without contextual background (i.e. appropriate graphics, proper units, etc.).	(0 points) Solution is not provided.

ANALYSIS & ASSESSMENT OF MODEL (3 POINTS TOTAL)			
IDEAL	**SATISFACTORY**	**NEEDS IMPROVEMENT**	**INCOMPLETE**
(3 points) The viability and reliability of the math modeling solution are addressed. For example, how sensitive is the model to changes in parameter values or altered assumptions? How does it compare to other solutions or historical data?	(2 points) Addressed, but the analysis is lacking proper dimensionality. For example, obvious consequences of the stated outcome are ignored or well-known comparisons are disregarded.	(I point) Some analysis is provided but without any sense of perspective.	(0 points) No analysis or assessment of model is included in the write-up. Incorrect mathematics used in analysis.

WRITING STYLE & ORGANIZATION (5 POINTS TOTAL)			
IDEAL	**SATISFACTORY**	**NEEDS IMPROVEMENT**	**INCOMPLETE**
(5 or 4 points) Correct spelling and grammar is used throughout. Paper is well formatted and enjoyable to read. Visual aids (if appropriate) are well chosen and easy to interpret.	(3 or 2 points) Multiple spelling, formatting or grammatical errors. Visual aids are missing key readability features or do not clearly connect to the solution.	(I point) Significant disregard for common spelling, grammatical and mathematical rules.	(0 points) Complete disregard for common spelling, grammatical and mathematical rules.

TABLE D.4: A GENERIC RUBRIC USED TO ASSESS STAND-ALONE EXECUTIVE SUMMARIES.

MATH MODELING PRESENTATION SCORE SHEET

Presentation made by team:

Please select a value (1-5) reflecting the extent to which you agree with the given statement.

	STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
I understood the presenting team's interpretation of the question.	1	2	3	4	5
All stated assumptions were adequately justified.	1	2	3	4	5
The model's strengths and weaknesses were addressed.	1	2	3	4	5
Appropriate mathematics was used to create the model.	1	2	3	4	5
A final solution was clearly presented.	1	2	3	4	5
The mathematical model produced a plausible result.	1	2	3	4	5
Visual aids were easy to read and understand.	1	2	3	4	5
The team addressed authentic alternative scenarios and/or the need for future work.	1	2	3	4	5
I enjoyed the presentation; the presenter(s) held my attention for the full extent of the talk.	1	2	3	4	5
I would like to learn more about this team's solution method.	1	2	3	4	5

What is one question you would like to ask this team?

Additional questions or comments:

TABLE D.5: A RUBRIC FOR PEER ASSESSMENT OF ORAL PRESENTATIONS OF MATHEMATICAL MODELING RESULTS. (ADAPTED FROM GALLUZZO AND WENDT)[1]