Modeling Method and NGSS Science & Engineering Practices Overview

Model Development (Guided Inquiry)

Pre-Laboratory Discussion

1. Demonstration – Teacher demonstrates a system to be studied, e.g. moving vehicle, syringe with movable plunger, etc. Students make observations.
2. The teacher records ALL student observations on the board in the front of the room without judgment of each observation.
3. The teacher elicits what quantities in the system demonstrated can be measured; i.e., what can be measured to study in this system and what equipment can be used to make each measurement.
4. The teacher guides the students to identify what factors in the system affect other factors. This leads to the identification of the independent, dependent and controlled variables in the experiment.
5. The teacher and students negotiate a possible procedure(s), bearing in mind the available equipment, for the experiment.

Conducting the Experiment:

Using the procedure developed in class, each group performs the investigation (alternate approaches may be used)

Model Development (Scientific Argumentation)

Whiteboarding:

1. Each group presents its results in a **whiteboard session**. (Whiteboards are not typically graded.)

   A whiteboard typically contains the following:

- Identification of variables (e.g., dependent, independent, controlled)
- Diagram of set up – no procedure; the procedure is to be stated or demonstrated during the presentation
- Sample data in table format if appropriate
- Graph showing trend of data (with labeled axes)
- Any mathematically determined relationships between the variables

3. The purpose of the **whiteboard session** is for students to work together to make sense of the results of their experiment. It is important that the teacher constantly emphasize to the students: "What do you know and how do you know it?" Their conclusions **must** be based on their observations (data).
4. The teacher facilitates the discussion, encouraging students to chime in, but **avoids commenting** on whether the results of any group are right or wrong.
5. It is important that students understand that **audience participation** is a vital part of the whiteboard presentations.
6. From the presentation of their whiteboarded findings, the class should reach consensus about the relationship between the variables being studied.

ASK QUESTIONS AND DEFINE PROBLEMS

- I formulate empirically answerable questions
- I establish what is already known
- I determine what questions have yet to be answered.
- I define constraints and specifications for a solution

USE MATHEMATICS AND COMPUTATIONAL THINKING

- I use technology to collect and analyze data

PLAN AND CARRY OUT INVESTIGATIONS

- I identify questions to be investigated.
- I identify variables and controls
- I design and perform experiments to test my hypotheses. I decide what data will be collected and how much, and what tools are needed.

ANALYZE AND INTERPRET DATA

- I use tables, graphs, spreadsheets, etc. to display and analyze data.
- I recognize patterns in data and see relationships between variables.

USE MATHEMATICS AND COMPUTATIONAL THINKING

- I use mathematics and statistics to analyze data.
- I express relationships between variables by writing mathematical models or equations.

ENGAGE IN AN ARGUMENT FROM EVIDENCE

- I defend my explanation.
- I formulate evidence based on solid data.
- I examine my own understanding in light of the evidence.
- I collaborate with my peers in searching for the best explanation.

DEVELOP AND USE MODELS

- I construct mental and conceptual models to represent and understand phenomena.

Model Deployment (Refinement & Summary)

Laboratory Report:

1. This is a formal write-up turned in by each student.
2. Contents include: Purpose, Apparatus, Procedure, Raw Data, Analysis of Data (graphs, calculations, mathematical relationships, etc...), Discussion, and Conclusion.
3. The members of a lab group can share the same procedure (since it has been developed by the group) and the data. Everything else is to be each individual student's own work. This includes graphs, calculations and data analysis, discussion, and conclusion. Group members collaborate to help one another reach consistent conclusions.
4. To help get students involved in participating in the whiteboard discussion sessions, part of the lab report discussion **must include a comparison** of a group's results with the other groups in the class. Specifically, the discussion should include what others did differently and how or why their results were the same or different. It is expected that each group will have done slightly different procedures, and similarities and differences should be discussed during the **whiteboard session.** Students are expected to pay attention and contribute during these sessions, and they might want to jot down a few notes to refer to when writing their lab report.

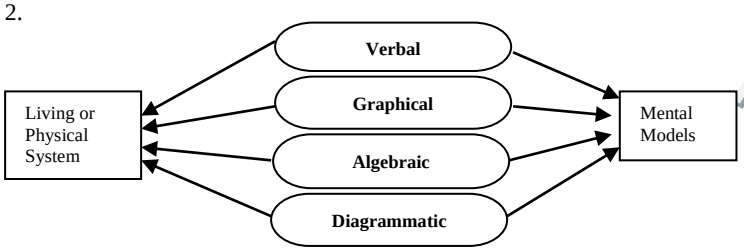
ANALYZE AND INTERPRET DATA

- I revise my initial hypothesis when the data doesn't support it.

OBTAIN, EVALUATE AND COMMUNICATE INFORMATION

- I communicate findings clearly and persuasively.
- I derive meaning from scientific text.
- I engage in discussions with scientific peers.
- I evaluate the validity of the findings of others.

Post-Laboratory, Model Refinement and Application:

1. The class summarizes the findings of the class with multiple representations, whenever possible.
2. 

3. After summarizing the concepts and descriptions applicable to the system being studied, the teacher may introduce conventional terminologies that apply to the concepts.
4. The teacher helps students extract key features of the model from the context in which it was first examined and apply it to related phenomena. Students solve problems on worksheets or perform further investigations using reasoning and argumentation (rather than using "plug and chug" algorithms). **Cognitive dissonances** that allow for mistakes are provided such that alternative conceptions surface and scientific argumentation ensues. Students decide which model is best suited to make sense of a problem. When a model's shortcomings become apparent, students look to either modify it or develop a new one. Teaching strategies at this stage include (but are not limited to) scaffold problems, context-rich problems, complex-conceptual questions, goal-less problems, concept maps, and model summary boards. Models are refined and reinforced during **whiteboard sessions**.
5. Quizzes are given throughout a unit and a test is given as summative assessment.

DEVELOP AND USE MODELS

- I construct mental and conceptual models to represent and understand phenomena.
- I use models to explain and predict behaviors of systems, or test a design.
- I refine my models in light of new empirical evidence.

Model Deployment (Integration & Transfer)

Laboratory Practicum / Engineering Application:

1. For some units it is useful to test the students' understanding through either a laboratory practicum or engineering application. This is a good review as it often demands that the students understand and use all concepts covered up to this point in the course.

ANALYZE AND INTERPRET DATA

- I analyze a performance of a design under a range of conditions.

CONSTRUCT EXPLANATION AND DESIGN SOLUTIONS

- I evaluate information and form hypotheses.
- I construct explanations or models of phenomena.
- I design a variety of solutions to a problem.

USE MATHEMATICS AND COMPUTATIONAL THINKING

- I use mathematical models and computer simulations to test my predictions and designs.