Tshwane University of Technology

We empower people

You Have a DREAM

That's Why You Are Here

We Are Here

To Make That DREAM Come TRUE

Tshwane University of Technology

We empower people

MODELING AND SIMULATION

MSI118G

By

William T Vambe (Ph.D)

IMAGINE

You are holding a cup of coffee when someone comes along and bumps into you or shakes your arm, making you spill your coffee everywhere.

Why did you spill the coffee????

William Tichaona Vambe (Ph.D) • You
Lecturer and Researcher
1d •

I LOVE THIS ANALOGY:
You are holding a cup of coffee when someone comes along and bumps into you or shakes your arm, making you spill your coffee everywhere.
Why did you spill the coffee?
"Because someone bumped into me!!!"
Wrong answer.
You spilled the coffee because there was coffee in your cup.
Had there been tea in the cup, you would have spilled tea.
Whatever is inside the cup is what will spill out.
Therefore, when life comes along and shakes you (which WILL happen), whatever is inside you will come out. It's easy to fake it, until you get rattled.
So we have to ask ourselves... "what's in my cup?"
When life gets tough, what spills over?
Joy, gratitude, peace and humility?
Anger, bitterness, victim mentality and quitting-tendencies?
Life provides the cup, YOU choose how to fill it.
Today let's work towards filling our cups with gratitude, forgiveness, joy, words of affirmation, resilience, positivity; and kindness, gentleness and love for others.

Outcome

By the ~~end of the unit, you should be able to:~~

B.1.1 - By means of a taxonomic diagram, types of models are described with examples.

B.1.2 - By means of a taxonomic diagram, Model building approaches are described with their salient features.

B.1.3 - Constructs and concepts of a particular modelling approach are explained with an illustrative problem- solving example.

B.1.4 - Relative advantages and disadvantages of model building approaches are discussed with illustrative examples.

B.1.5 - Five steps in the Model building process are explained by means of a schematic flow diagram.

B.1.6 - The use of practical software tools for model building is demonstrated with a practical problem-solving example.

B.1.7 - A formal mathematical model of a real-world problem- solving situation is created.

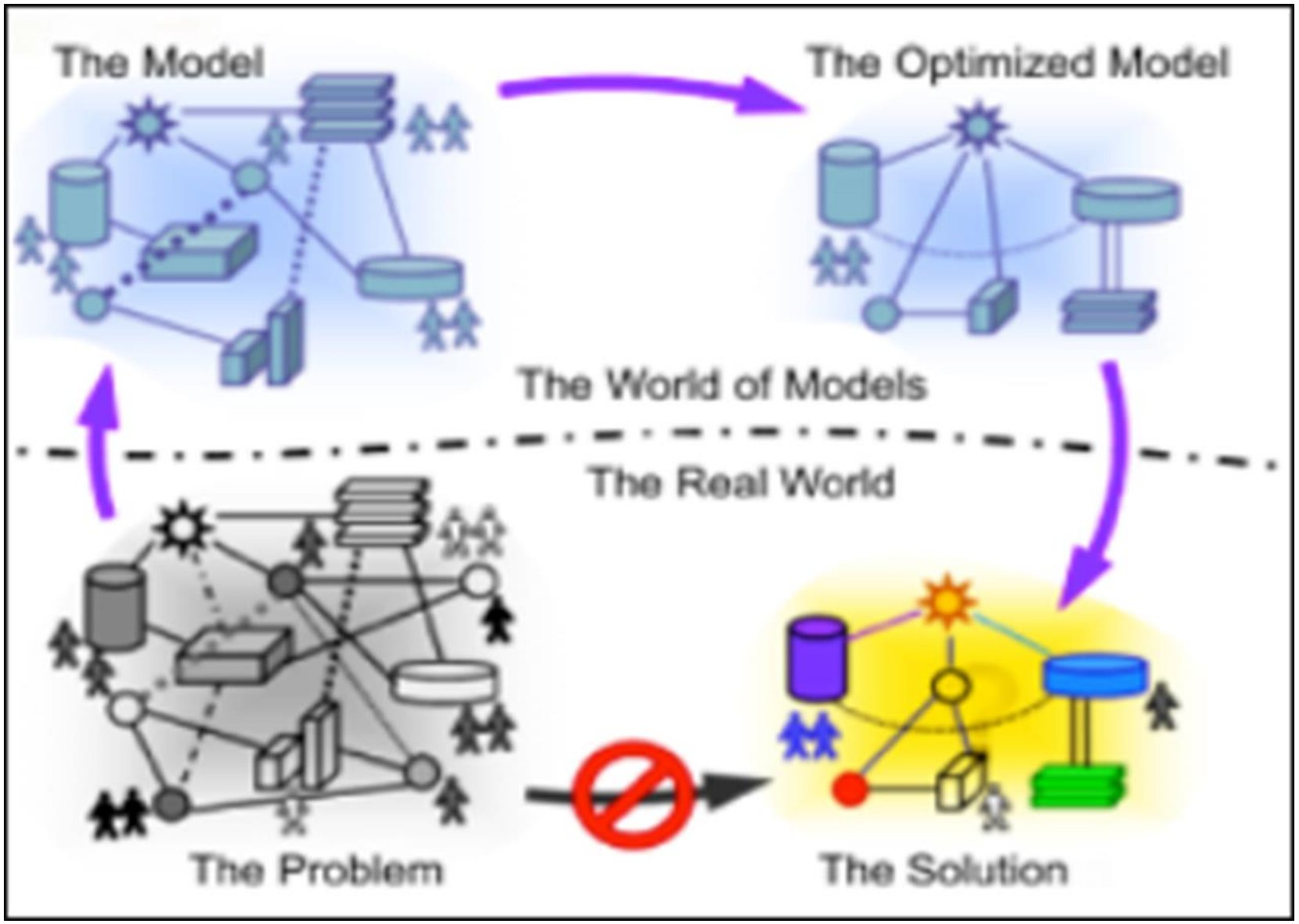
B.1.8 - Appropriate modelling approach for a given problem or situation is chosen using standard criteria.

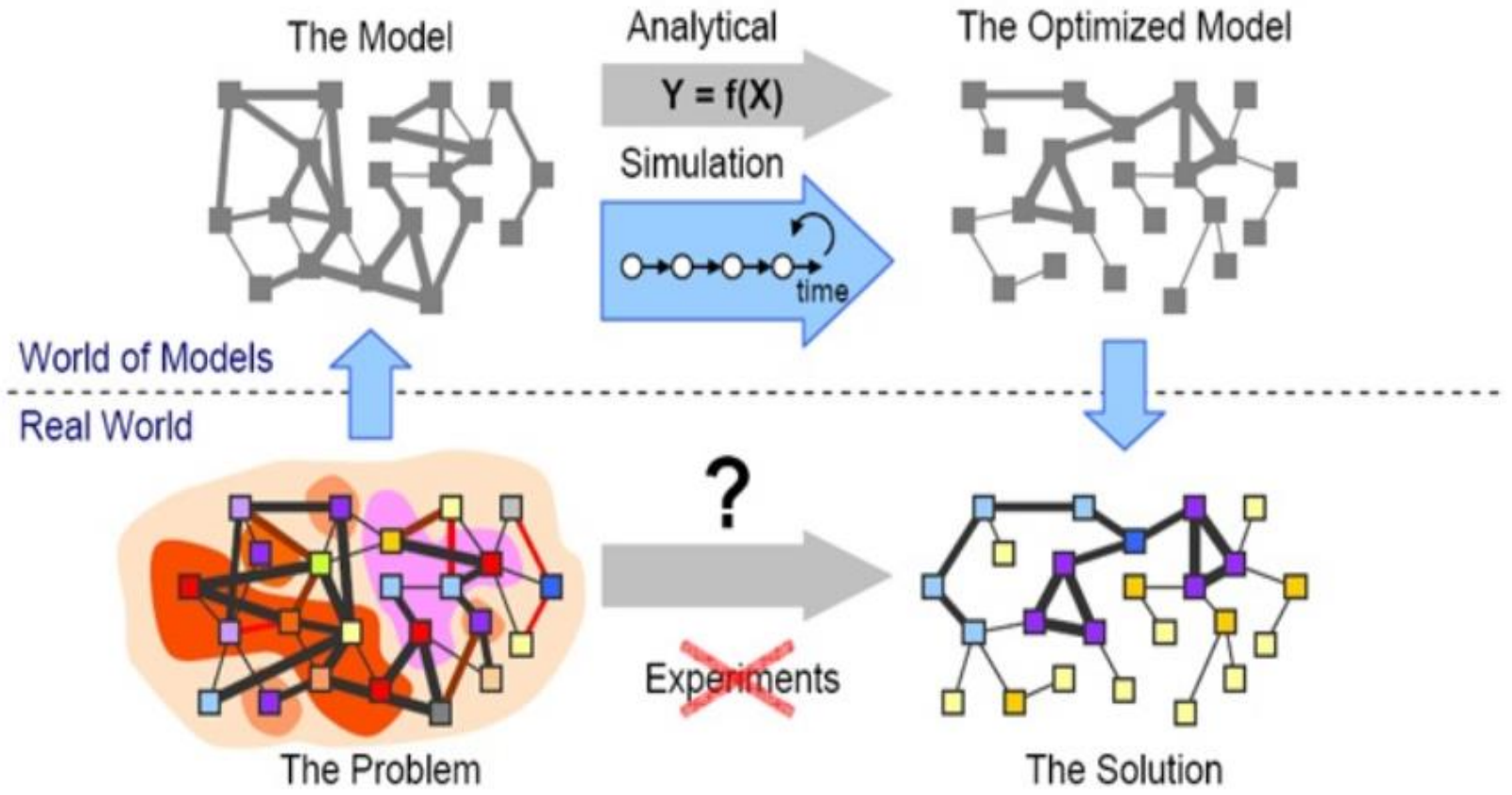
B.1.9 - A model built is appropriate for problem domain requirements such as optimization; supporting decision making, forecasting, safety considerations; for training and education.

B.1.10 - An existing model is extended and adapted to a new problem situation

Recommended Reading and Resources

- Uri Wilensky and William Rand (2016), An Introduction To Agent-Based Modeling: Modeling Natural, Social, and Engineering Complex Systems with NETLOGO.
- Juan Carlos Garcia Vazquez and Fernando Sancho Caparrini, 2014. NetLogo, A modelling tool.


The Model
The Optimized Model
The World of Models
The Real World
The Problem
The Solution


The Model
Analytical
Y = f(X)
Simulation
time
The Optimized Model
World of Models
Real World
?
Experiments
The Problem
The Solution

Recap- B.1.1 Types of Models

- **Models are simplified representations of systems or phenomena, used to understand, predict, or control their behavior**
- https://www.youtube.com/watch?v=X-6zxImekOE

Recap- B.1.1 Types of Models

- Models are simplified representations of systems or phenomena, used to understand, predict, or control their behavior
- ├── Physical Models
- │ ├── Scale Models (e.g., architectural mock-ups)
- │ └── Prototypes (e.g., product samples)
- ├── Mathematical Models
- │ ├── Statistical Models (e.g., regression models)
- │ └── Differential Equations (e.g., population growth models)
- ├── Conceptual Models
- │ ├── Flowcharts (e.g., process diagrams)
- │ └── Mind Maps (e.g., brainstorming sessions)
- └── Simulation Models
- │ ├── Discrete Event Simulation (e.g., queuing systems)
- │ └── Agent-Based Simulation (e.g., crowd dynamics)

B.1.2 Model Building Approaches

- Model building approaches can be classified based on their development process and underlying assumptions.
- ├— Top-Down Approach
  - ├— Starts with a general system overview
  - ├— Breaks down into detailed sub-components
  - └— Useful for complex systems with clear hierarchies

Example: Designing an enterprise IT architecture starting from overall system requirements down to specific software modules.

- ├— Bottom-Up Approach
  - ├— Begins with detailed components
  - ├— Integrates to form the complete system
  - └— Effective when system behavior emerges from interactions

Example: Developing individual software functions and integrati them to form a complete application.

B.1.2 Model Building Approaches

- Model building approaches can be classified based on their development process and underlying assumptions.
- ├— Data-Driven Approach
  - ├— Relies on empirical data
  - ├— Utilizes statistical and machine learning methods
  - └— Ideal for systems where theoretical models are inadequate

Example: Using customer purchase history to build a recommendation system

- └— Theory-Driven Approach
  - ├— Based on established theories and principles
  - ├— Develops models through logical deduction
  - └— Suitable for well-understood systems

Example: Applying Newton's laws of motion to model the trajecto of a projectile.

B.1.4 Relative Advantages and Disadvantages of Model Building Approaches

1. Top-Down Approach:

Advantages:

- Provides a clear system overview.
- Ensures alignment with organizational objectives.

Disadvantages:

- May overlook intricate component details.
- Can be inflexible to changes in sub-components.

2. Bottom-Up Approach:

Advantages:

- Focuses on detailed component functionality.
- Encourages innovation at the subsystem level.
- Disadvantages:
- Risk of misalignment with the overall system purpose.
- Integration of components can be challenging.

B.1.4 Relative Advantages and Disadvantages of Model Building Approaches

3. Data-Driven Approach:

Advantages:

- Adapts to real-world data, capturing complex patterns.
- Continuously improves with more data.

Disadvantages:

- Requires large datasets, which may not always be available.
- Models can become overfitted to historical data, reducing generalizability.

4. Theory-Driven Approach:

Advantages:

- Grounded in established scientific principles.
- Provides clear explanations for model behavior.

Disadvantages:

- May not capture unforeseen real-world complexities.
- Can be rigid, limiting adaptability to new data

B.1.3 Constructs and Concepts of a Particular Modeling Approach

- **Example: Data-Driven Approach in Predictive Analytics**

Constructs and Concepts:

- **Data Collection:** Gathering relevant historical data.
- **Feature Selection:** Identifying variables that influence the outcome.
- **Model Selection:** Choosing appropriate algorithms (e.g., linear regression, decision trees).
- **Training and Validation:** Splitting data to train the model and validate its performance.
- **Prediction:** Applying the model to new data to forecast outcomes.

B.1.3 Constructs and Concepts of a Particular Modeling Approach

- Illustrative Example: A retail company wants to predict future sales based on past performance.
- **Data Collection:** Compile sales data over the past five years, including variables like advertising spend, seasonal factors, and economic indicators.
- **Feature Selection:** Determine that advertising spend and seasonal factors are significant predictors.
- **Model Selection:** Opt for a linear regression model to establish the relationship between sales and selected features.
- **Training and Validation:** Use 80% of the data to train the model and 20% to validate its accuracy.
- **Prediction:** Apply the model to forecast sales for the upcoming quarter, aiding in inventory and marketing strategies.

To do

- Look for other examples of other approaches

B 1.5 Five Steps in the Model Building Process

- The model-building process is a structured approach to developing a reliable representation of a system, enabling analysis, prediction, and decision-making.
- The model-building process involves a series of systematic steps to develop a reliable representation of a system.

1. Problem Definition
   ↓
2. System Analysis
   ↓
3. Model Formulation
   ↓
4. Model Validation
   ↓
5. Implementation and Monitoring

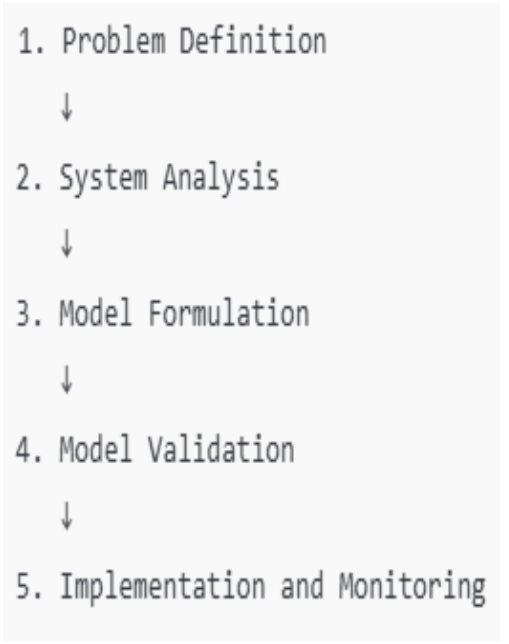
B 1.5 Five Steps in the Model Building Process

1. Problem Definition

- **Objective:** Clearly articulate the issue or system to be modeled.

Actions:

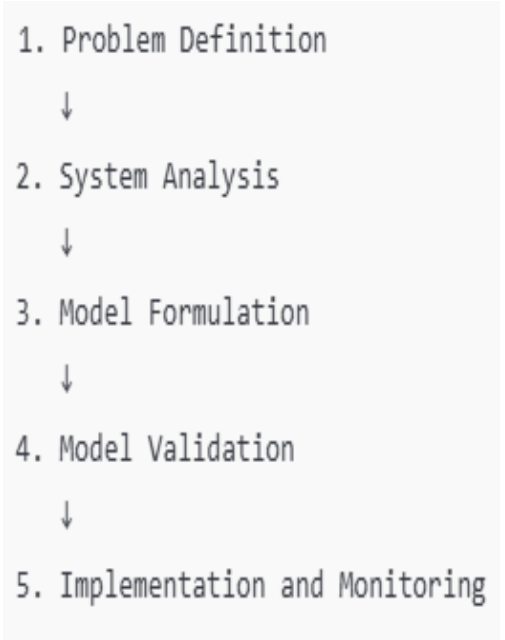
- Identify the specific problem or question to address.
- Determine the goals and objectives of the model.
- Establish the scope and boundaries of the system.



B 1.5 Five Steps in the Model Building Process

2. System Analysis

- **Objective:** Understand the components and dynamics of the system.
- **Actions:**
- Collect relevant data and information about the system.
- Identify key variables, parameters, and their relationships.
- Analyze system behavior and constraints.



B 1.5 Five Steps in the Model Building Process

3. Model Formulation

Objective: Develop a conceptual or mathematical representation of the system.

Actions:

- Choose the appropriate modeling approach (e.g., mathematical equations, simulations).
- Define assumptions and simplifications.
- Construct the model using the identified variables and relationships.

1. Problem Definition
   ↓
2. System Analysis
   ↓
3. Model Formulation
   ↓
4. Model Validation
   ↓
5. Implementation and Monitoring

B 1.5 Five Steps in the Model Building Process

4. Model Validation

- **Objective:** Ensure the model accurately represents the real system.
- **Actions:**
- Compare model outputs with real-world data.
- Perform sensitivity analysis to test the model's robustness.
- Refine the model as necessary to improve accuracy.

1. Problem Definition
   ↓
2. System Analysis
   ↓
3. Model Formulation
   ↓
4. Model Validation
   ↓
5. Implementation and Monitoring

B 1.5 Five Steps in the Model Building Process

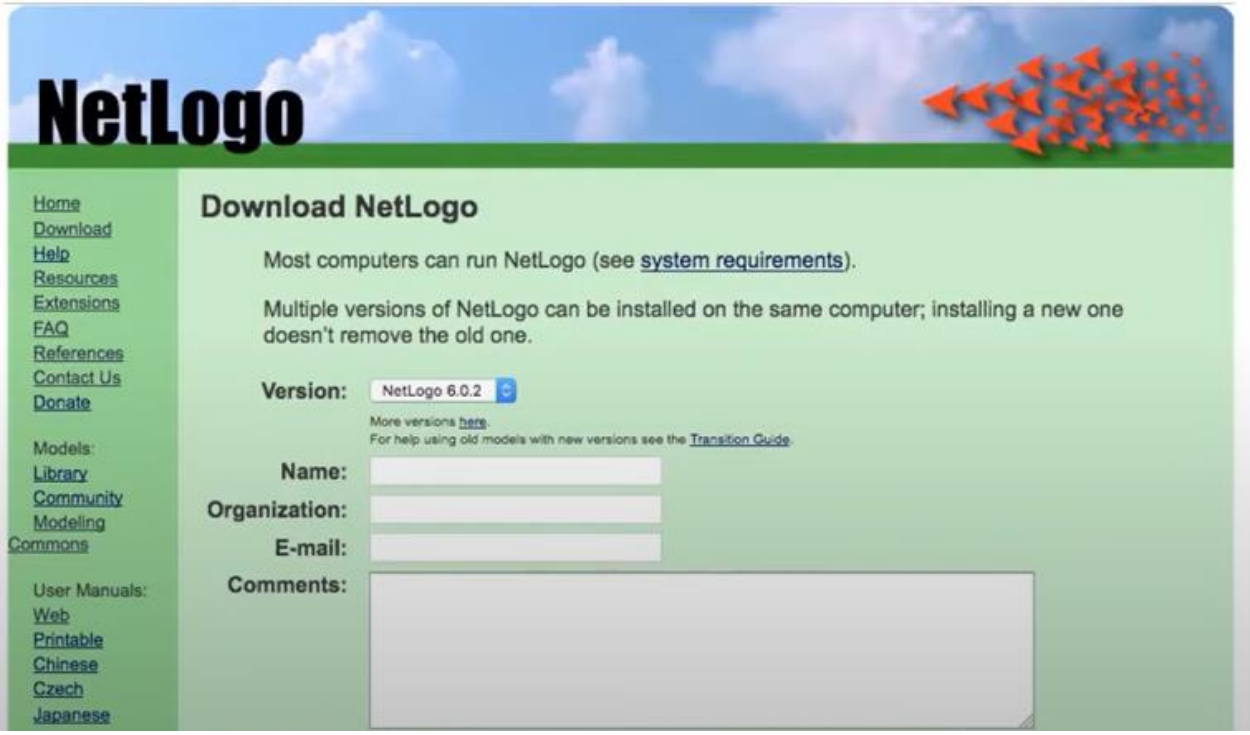
5. Implementation and Monitoring

- **Objective:** Apply the model to make decisions and monitor its performance.
- **Actions:**
- Integrate the model into decision-making processes.
- Implement recommended solutions or strategies.
- Continuously monitor outcomes and update the model as needed.

1. Problem Definition
   ↓
2. System Analysis
   ↓
3. Model Formulation
   ↓
4. Model Validation
   ↓
5. Implementation and Monitoring

Install NetLogo

Go to https://ccl.northwestern.edu/netlogo/download.shtml



I REST MY CASE

THANK YOU
Q & A

VAMBE
WILLIAM T