Designing an ABM

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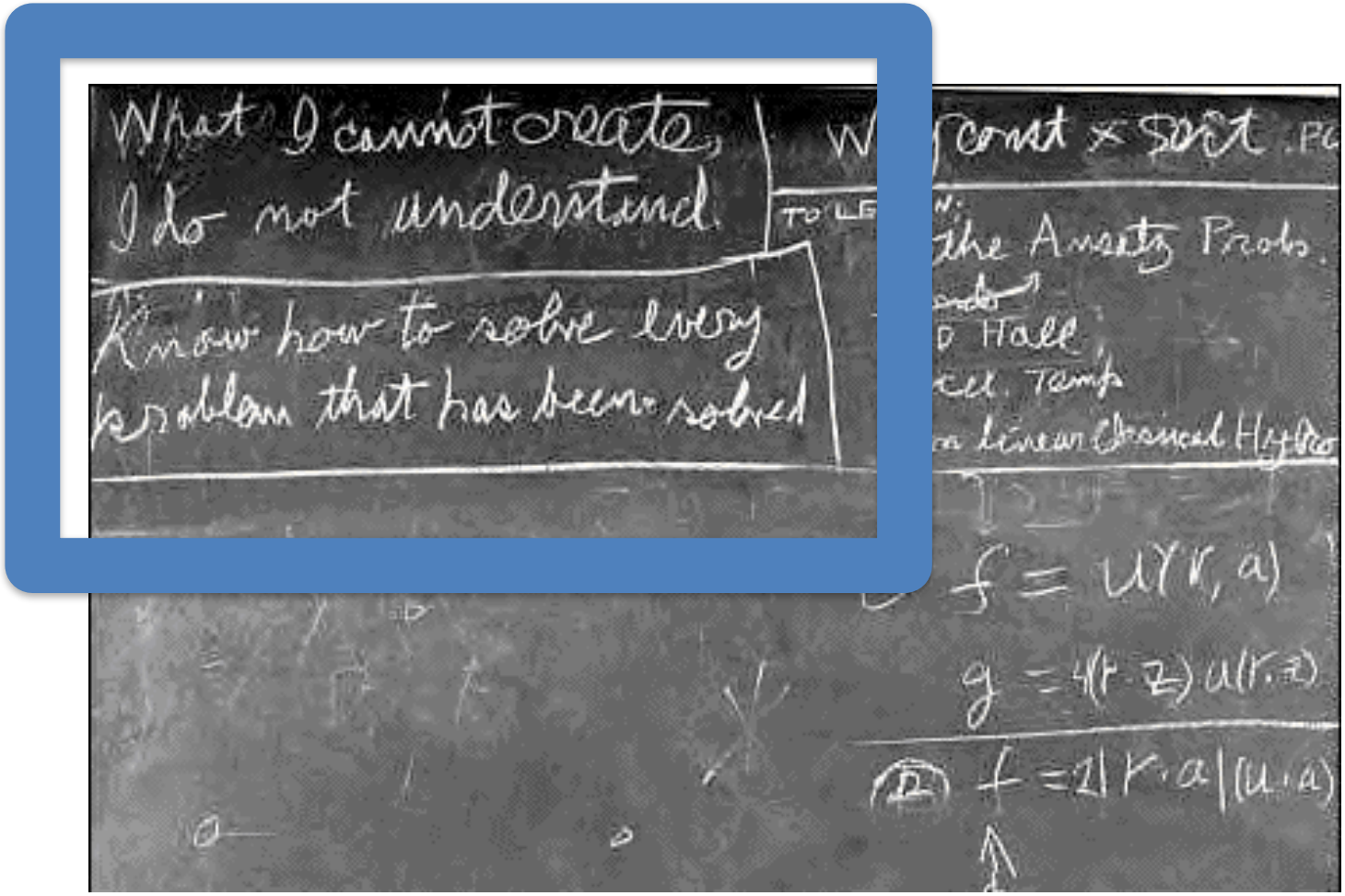
Generative Science



From Richard Feynman's blackboard around the time of his death.

Three Major Steps

1. Design the Model
2. Build the Model
3. Analyze the Model

Two Design Methods

1. Phenomena-Based Modeling

   When you know characteristic / reference pattern you want to model

2. Exploratory Modeling

   Starting with a basic set of mechanisms and then exploring what those mechanisms generate

Top-Down vs. Bottom-Up Design

- Almost all ABMs are bottom-up in terms of the model
- But Design can be approached form either a bottom-up or top-down approach:
  - Top-Down: Start with the components and the design and then put them together
  - Bottom-Up: Conceptual model and code co-evolve to create the model
- It is rare that a designer uses any of these methods exclusively

The ABM Design Principle

Start Simple and
Build Toward the Question
You Want to Answer.

Design Simplicity

"The supreme goal of all theory is to make the irreducible basic elements as simple and as few as possible without having to surrender the adequate representation of a single datum of experience." - Albert Einstein

"Do not multiply entities unnecessarily" - William of Ockham

"Keep It Simple, Stupid" - Robert Axelrod

Advantages of Simplicity

- Helps confirm that all mechanisms are necessary
- Easier to understand
- Facilitates verification and validation
- Allows you to more easily examine components

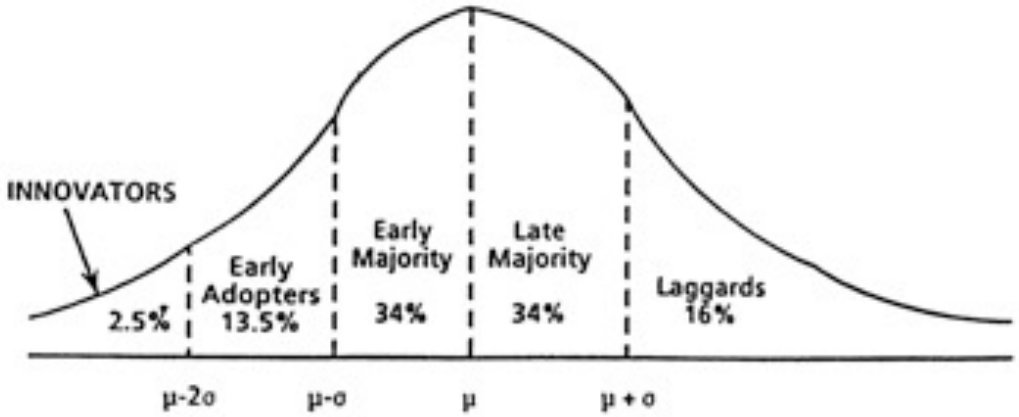
Build Toward a Question

"All models are wrong, but some models are useful." - George Box

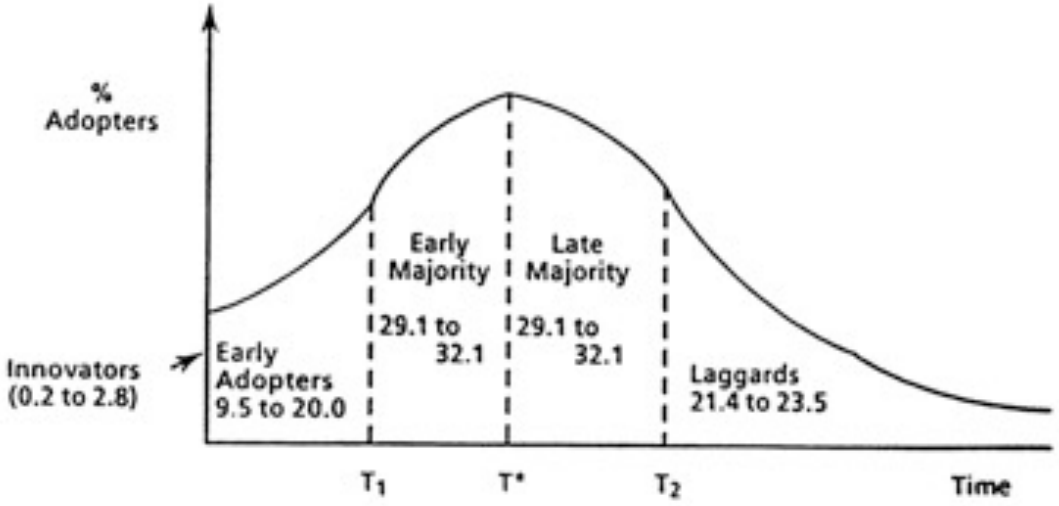
Do not add content that does not help you answer the question at hand, even if it would make the model "more realistic."

A Concrete Example

- Throughout this unit we will building an agent-based model from the ground-up
- In this case, we will be building a model of new information diffusion through a population
- For instance, how do people find out about a new product to buy? Or learn which candidate to vote for?
- Our basic question is “How does novel information diffuse through a population over time?”



A. The Rogers Adopter Categories.



B. The Bass Adopter Categories.*

* The percentage range reported for each category is based on the parameter estimates reported by Bass (1969).

Source: Mahajan, Muller, and Srivastava (1990).

FIGURE 2. A Comparison Between the Bass Model and Classical Normal Distribution Model.

Diffusion

Bass Model

$h(t) = p + qF(t)$

- $h(t)$ = rate of adoption, given not adopted so far
- $F(t)$ = cumulative fraction of adopters

Parameters

- p = coefficient of innovation; tendency to adopt independent of social contagion
- q = coefficient of imitation; tendency to adopt due to social contagion
- m = market size

Bass, 1969
"A New Product Growth Model for Consumer Durables"

An Agent-Based Version

Setup *m* agents

Each time step agents determine if they will innovate on the basis of:

- p_a – innovation
- q_a – imitation on the basis of other adopters
  - $q_a(n_t/m)$

Observe number of adopters

Seven Design Choices

1. What part of your phenomenon would you like to build a model of? (Scope / Question)
2. What are the principal types of agents involved in this phenomenon? (Agents)
3. What properties do these agent have (by agent type)? (Properties)
4. What actions or behaviors can these agents take (by agent type)? How do these agents interact with each other or with the environment? (Behaviors)
5. In what kind of environment do these agents operate? Are there environmental agents? (Environment)
6. If you had to define the phenomenon as discrete time steps, what events would occur in each time step, and in what order? (Time Step)
7. What do you hope to observe from this model? (Inputs and Outputs)

Scope and Question

- Before any design, make sure that it makes sense to model your question using ABM (see Unit 1)
- Refine the research question in light of these advantages
  - Network Heterogeneity
  - Local but Complex Interactions
  - Some individuals may have more information sources than others
- “How does novel information diffuse through a population embedded in a social network based on both broadcast and local information drivers?”

Agents

- What are the agents in the model?
- Granularity / Level of the agent (related to temporal scale of interest)
  - Cellular-level
  - Organizational-level
  - Individual-Human Level
- Proto-agents
  - Agents that do not have their own properties / behaviors but may in the future, e.g., Broadcast media
- Diffusion example - Human Individuals (maybe two types?), Network Connections, and Media

Properties

- What properties do the agents have?
- Diffusion
  - Do they have the information?
  - Effect of Social Influence
  - Effect of Broadcast Media
- Links and Media will not have separate properties now, but could in the future

Behaviors

- What do the agents do?
- Diffusion
  - Decide to adopt the information or not?

Environment

- What is the environment within which the agents act?
- Diffusion
  - The Social Network
  - To some extent Media

Time Step

- What happens in a single time step of the model?
- Diffusion
  - Each agent decides whether or not to adopt the information
  - They update their internal state
  - Overall statistics are calculated

Inputs and Outputs

- Inputs / Parameters
  - Diffusion
    - The network structure
    - Effect of Social Influence
    - Effect of Mass Media
    - Number of Agents
- Outputs / Measures
  - Diffusion
    - Number of Adoptions over Time