Learning by Doing

A Path to Creating Original Modeling Projects

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Overview

• The best way to learn system dynamics thinking and modeling is by “doing” it through hands-on learning:

• **Project 1** – Modelling the Kaibab Plateau
• **Project 2** – Replicating classic or instructional models
• **Project 3** – Developing an original modeling project
Methodology

• Emphasis on practicing model building towards producing an original modeling project

• Students are guided through the following progression
  • Kaibab Plateau model – Understand the scenario and develop the model
  • Replication model – Understand and develop classic or instructional system dynamics models
  • Original model – Develop a model based on a self-selected problem

• Project progression (for the replication and original modeling projects)
  1. Conceive a project
  2. Submit a written proposal
  3. Present the proposal orally
  4. Present a progress report orally
  5. Present a final oral and written report

• Learn by
  • Doing – Student volunteers use the software in class
  • Practicing – Students are provided with tutorial videos via Camtasia
  • Experimentation – Students self-learn through trial and error
Using Vensim

• Vensim PLE is the software tool used for modeling

• Vensim manuals are used to self-learn
  • Instructor comments are provided as supplements

• Vensim models and model documentation are used for replication

• Focus
  • Mastering Vensim is not the focus of the class; Vensim is a tool to learn and practice system dynamics modeling
  • Developing skills in crafting and presenting projects is the focus
This is a practice course, not a reading one, but readings supplement and provide context for the modeling practice

- **Vensim** – Vensim manuals
Kaibab Plateau Modeling Exercise

• Goal
  • Develop a common technical language for the class using a model that is simple and “concrete”

• Timeframe
  • Three weeks (6-9 hours in class) from first lesson to final project submission

• Purpose
  • Not to build the model correctly, but to understand why the model is constructed the way it is

Source:
http://www.fs.fed.us/wildflowers/regions/southwestern/KaibabPlateau/images/kaibab_plateau_map_lg.gif
Kaibab Plateau Modeling Exercise

- Methodology
  - Sector-by-sector model construction, with each sector building on the previous
    - Deer
      - Population
    - Lions
      - Population with predation added
    - Food
      - Growth with consumption and regeneration added

- Model is constructed in class

- Completed model sectors are provided as a ‘check’ for students
Kaibab Plateau Modeling Exercise

- Reference Mode

**Figure 1**
Kaibab Plateau Modeling Exercise

- Deer Sector

fractional birth rate for deer

DEER initial value

DEER HERD GROWTH

DEER HERD DECLINE

deer density

land area

deer killed by lions

deer killed per lion

deer killed by lions

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Kaibab Plateau Modeling Exercise

• Lion Sector

fractional birth rate for lions

LIONS Initial Value

LION POP DECLINE

average lifetime of lions

lion deaths

LION POP GROWTH

lion births

lions killed

bounty beginning time

bounty ending time

fraction lions killed normal

fraction lions killed bounty
Kaibab Plateau Modeling Exercise

- Food Sector

Food initial value

Food growth

Food capacity

Food deficit

Food supply/capacity ratio

Food consumed per deer

Food consumed per deer

Food available per deer

Average lifetime of deer

Food regeneration

Time for food regeneration
Kaibab Plateau Modeling Exercise

- Advantages of Using Kaibab Plateau Model
  - Policy problem
    - Presents a policy intervention
    - Multiple stakeholder views
  - “Concrete” variables in a real-world context
    - Deer, lions, and vegetation
  - Clear reference mode
    - Data readily available
    - Shift in loop dominance
    - Cannot be re-created until model is completed
    - Closed (endogenous) system
  - “Classic” structures
    - Simple ecosystem
    - Population dynamics
      - Growth and regeneration
      - Overshoot phenomena
      - Example of sustainability
  - Allows for various policy intervention scenarios
Kaibab Plateau Modeling Exercise

• Demonstration (10 minutes)
  • Classroom teaching
  • Self-learning
  • Video recording
Replication Modeling Exercise

• “The training wheels are off”

• Goal
  • Replicate a classic or instructional system dynamics model while learning about new functions in Vensim

• Students choose a model based on their original project (samples)*
  • Business/Management
    • Capacity and Market Growth
    • Financial Modeling and Risk
    • Project Dynamics
    • Workforce, Inventory, and Oscillation
  • Other
    • Growth of a Field
  • Population
    • Population Dynamics
    • Urban 1
    • World 2

* These are selected by the instructor(s) based on student interest
Replication Modeling Exercise

- Methodology
  - Model context / background is given in class
  - Model is replicated outside of class
  - Additions, extensions, or adaptations are made to the model to fit student interests
    - Replicate the reference mode
      - Structure
        - Sectors
      - Content
        - Functions
        - Equations
    - Extend the model or create a policy intervention
  - Expands the domain for model diversity and policy and sensitivity analysis
Replication Modeling Exercise

• Demonstration (10 minutes)
  • Classroom teaching (replication document)
  • Self-learning via Vensim exercises
Original Modeling Exercise

• Are students capable of creating and presenting a policy-relevant system dynamics model?

• Goal
  • Develop an original model building upon knowledge gained from the Kaibab and replication projects
  • Create a quality project that can be used as a point of departure as a
    • Thesis/dissertation
    • Credential

• Students select a problem based on their interests
  • Problems are chosen in any field or subject
Original Modeling Exercise

- **Student topic areas (samples)**
  - **Education**
    - What explains the gap in academic performance between students from middle-income and low-income school districts in the USA?
  - **Energy**
    - What is delaying shifting to renewable energy in Singapore?
  - **Finance**
    - How did speculation create volatility in the housing market in Denmark?
  - **Governance**
    - What are the key factors affecting road accident fatalities in Delhi?
  - **Population**
    - What are the causes of declining fertility in Singapore?
  - **Urban Dynamics**
    - What are the economic factors that have caused net migration over the last three decades in Sri Lanka?
Original Modeling Exercise

- Demonstration (10 minutes)
  - Coaching
  - Self-learning and model development
Guest Speakers

Cities – Prof. K. E. Seetharam

Education – Deputy Principal Goh

Engineering – Prof. P. C. Lui

Health – Prof. Jim Thompson

Foundations of System Dynamics – Prof. George Richardson

Vensim – Prof. Bob Eberlein
Coaching and Feedback

• Evaluations
  • Project
    • After each project is complete
• Students
  • Proposal via oral and written reports
  • Interim via oral report
  • Final via oral and written reports
Coaching and Feedback

• Presentations
  • Emphasis is placed on quality presentations and presenting system dynamics information to those outside the field

• Support
  • **Group Work** – Working in groups is encouraged for mutual support and discussion of the material
  • **Coaching** – Regular coaching is provided on replication and original projects
  • Support
    • **Office hours** – Three sessions per week
    • **Modeling** – Encourage regular practice in Vensim
Benefits of this Approach

• Direct Immersion
  • Students start modeling on the first day of class and are modeling until the end of the semester

• Building Process
  • Students progress from copying a model, to replicating and expanding a model, to creating one

• Modular Structure
  • Each element can be separated from the other and re-organized per the needs of the teachers and students, and time constraints
Alternate Approaches

• **Drawbacks**
  • **Time and Workload Commitment**
    • Requires significant time from students and teachers
    • Coaching is key, but requires time for feedback and discussion
  • **Immersion**
    • Students are expected to work outside of class and keep up with the technical and theoretical aspects

• **Alternatives**
  • **Introduction**
    • Use a common game as an introduction, e.g. the Fish banks or beer game
  • **Replication**
    • Follow the Kaibab Plateau modeling exercise with two replication models of increasing complexity
    • Select a larger variety of models of increasing complexity for students to replicate
  • **Original Project**
    • Remove the original project
    • Focusing on technical learning rather than an original project
An Evolving Process

• Changes that we are implementing
  • Documentation
    • Develop, complete, and standardize teaching material
  • Replication
    • Select a larger variety of models for students to replicate

• Student comments for future implementation
  • Pacing
    • Spread projects more evenly to distribute workload
  • Vensim
    • Earlier education on more Vensim functions
Conclusion

• Proven
  • Long track record of quality student modeling projects

• Flexibility
  • Methodology has a common starting point but highly flexible in the progression through the intermediate (replication) and advanced (original) projects

• Feedback
  • Students appreciate consistent, detailed feedback
  • Gives confidence in replicating and modeling

• Systems Thinking
  • By modeling from the beginning of the class, students become more deeply grounded systems thinkers than if trained in systems thinking alone