35th International Conference of the System Dynamics Society
Cambridge, MA USA

Modeling Psychological and Sociological Dynamics

Methods and Applications

July 20, 2017

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Co-chairs, Psychology and Human Behavior SIG, System Dynamics Society

Let us step into the night and pursue that flighty temptress, adventure.

J.K. Rowling, Harry Potter and the Half-Blood Prince

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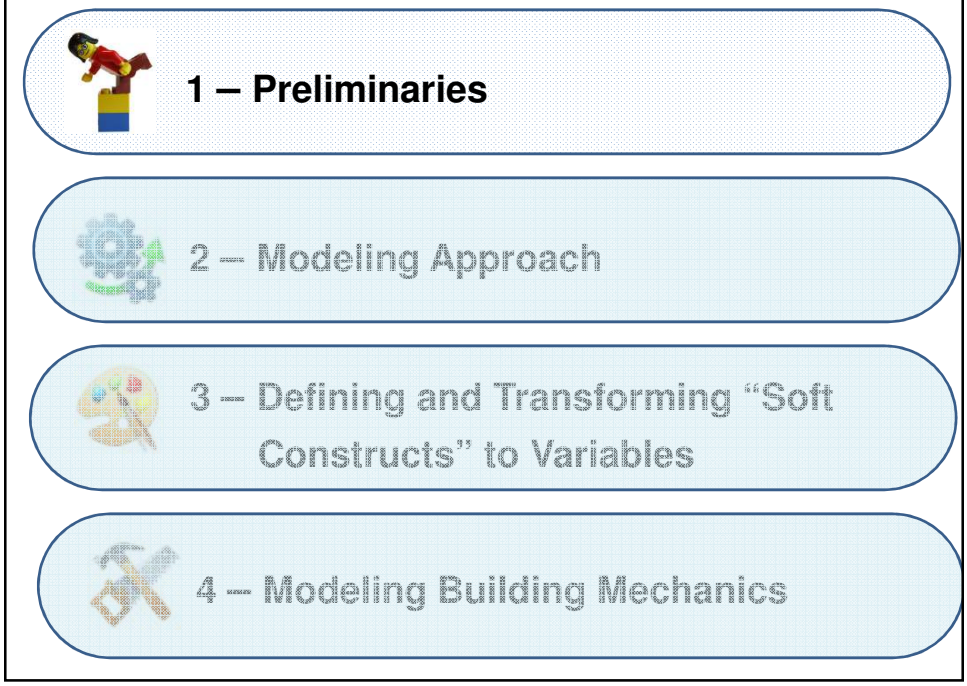


What do these words have in common?

motivation	satisfaction	anger
	depression	
distress	morale	happiness
enthusiasm	reputation	experience
media interest	fear	burnout
schedule pressure	service quality	stress

Construct

- Theoretical
- Often Qualitative

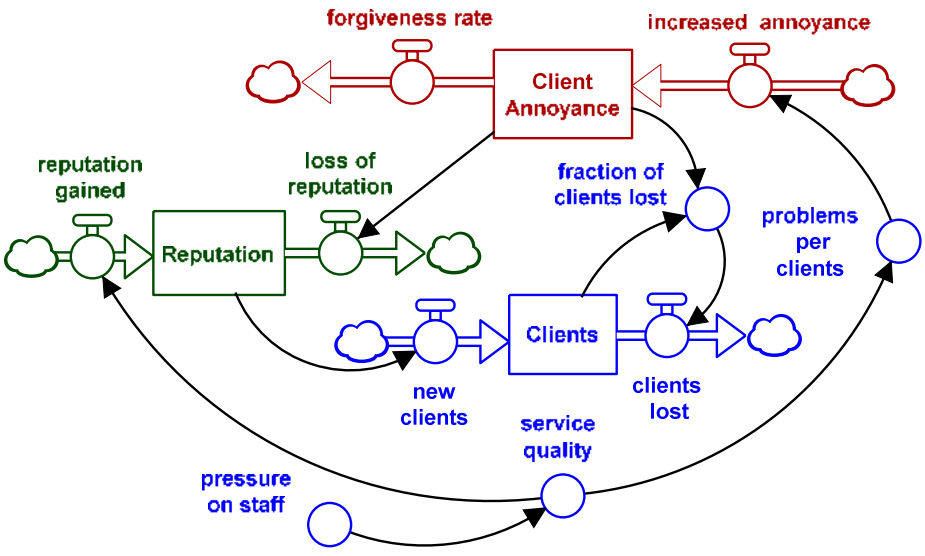
Operational Definition

Procedures to measure or assess construct

Variable

- Measurable
- Quantifiable

"Soft" Variable?



Adapted from Warren, Strategic Management Dynamics (2008)

Your Experience?

WORKSHOP EXPECTATIONS?

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Concerns about Soft Variables

They can't be used because they are intangible and can't be measured!

Non-material variables can't be used in "stock and flow" structures

It is bad practice to have more than one soft variable in a model

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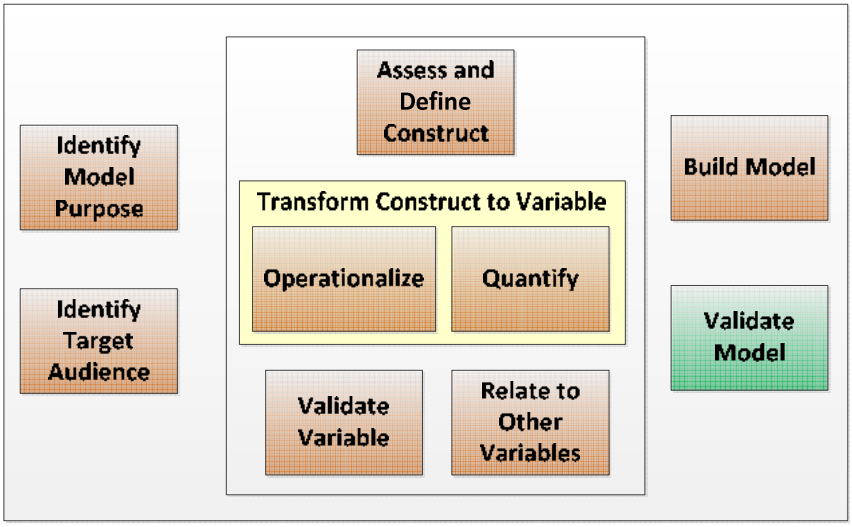
1 – Preliminaries

2 – Modeling Approach

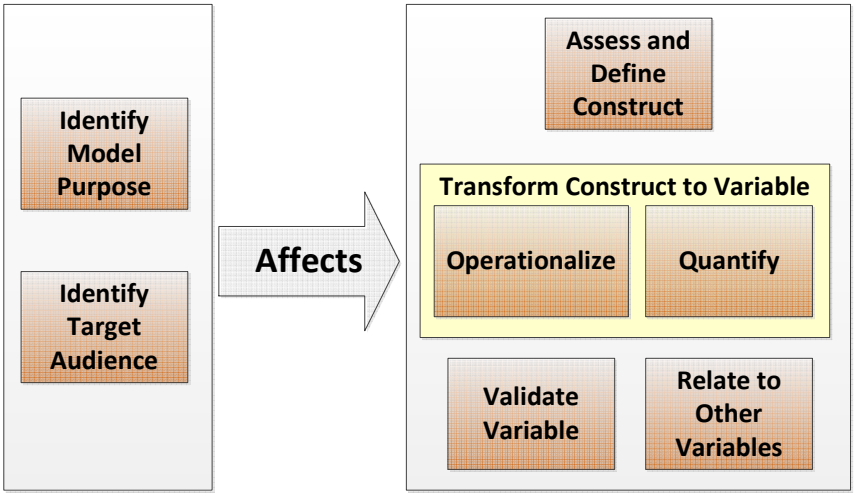
3 – Defining and Transforming "Soft Constructs" to Variables

4 – Modeling Building Mechanics

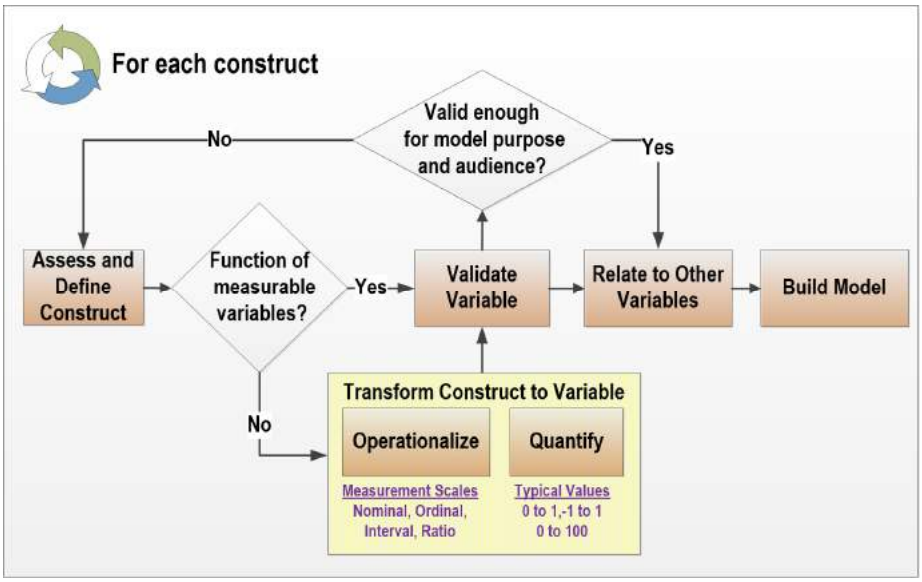
Modeling Activities



Key Point



Process Flow, and Rest of Workshop Agenda



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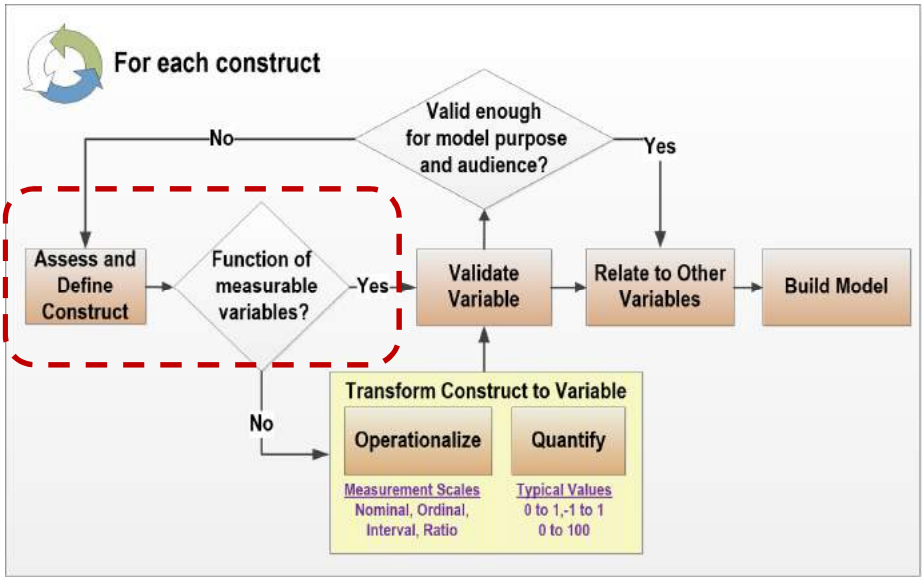
For each construct
Valid enough for model purpose and audience?
No
Yes
Assess and Define Construct
Function of measurable variables?
Yes
No
Validate Variable
Relate to Other Variables
Build Model
Transform Construct to Variable
Operationalize
Quantify
Measurement Scales
Nominal, Ordinal, Interval, Ratio
Typical Values
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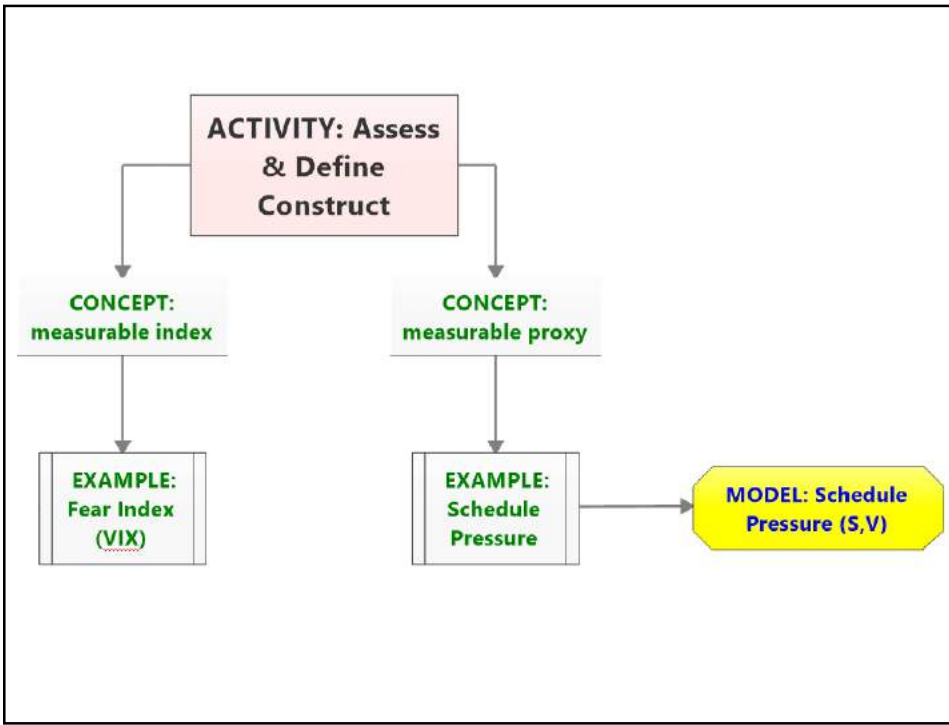
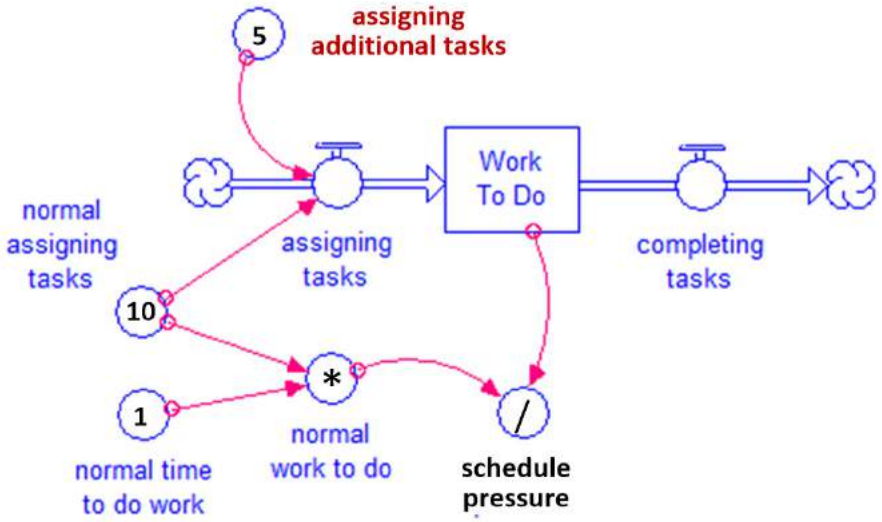

ACTIVITY: Assess & Define Construct
CONCEPT: measurable index
CONCEPT: measurable proxy
EXAMPLE: Fear Index (VIX)
EXAMPLE: Schedule Pressure
MODEL: Schedule Pressure (S,V)

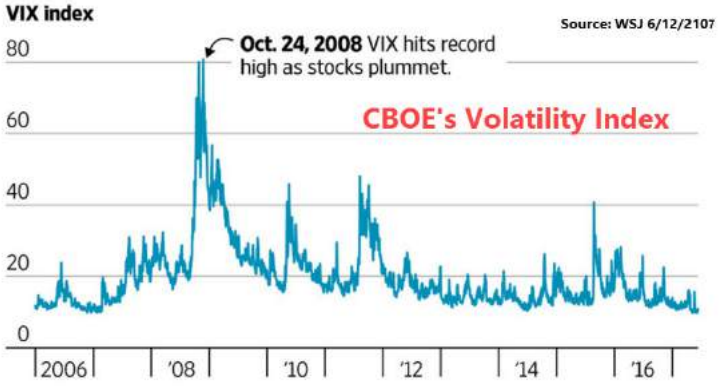
Proxy of "Measurable" Variable

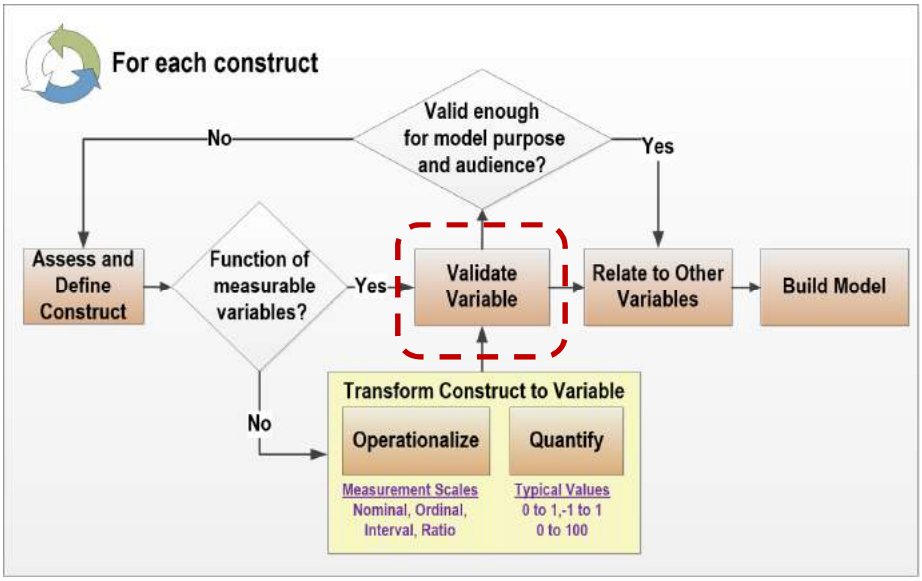


Schedule Pressure = (Work To Do) / (normal work to do)

"Bets Pile Up on Wall Street's Fear Index"

Wall St Journal June 13, 2017, print edition

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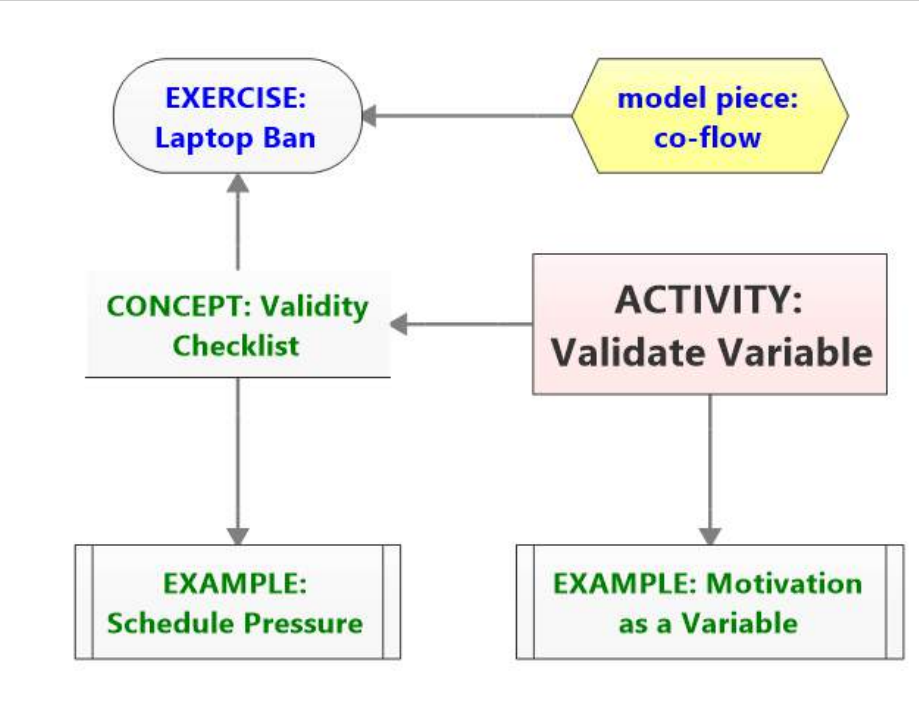
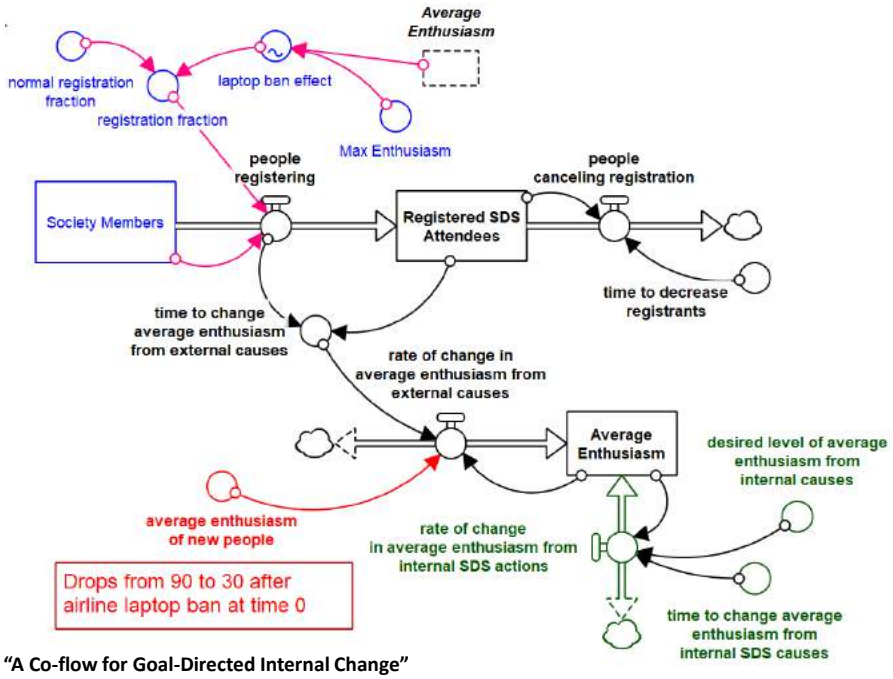

EXERCISE: Laptop Ban
model piece: co-flow
CONCEPT: Validity Checklist
ACTIVITY: Validate Variable
EXAMPLE: Schedule Pressure
EXAMPLE: Motivation as a Variable

NEWS FLASH
February 20, 2018

Complete Airline Laptop Ban Announced

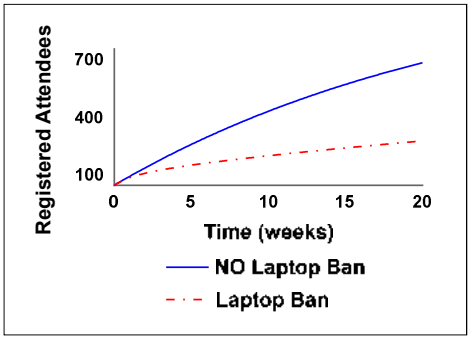
What is effect on SDS 2018 Conference Attendance?

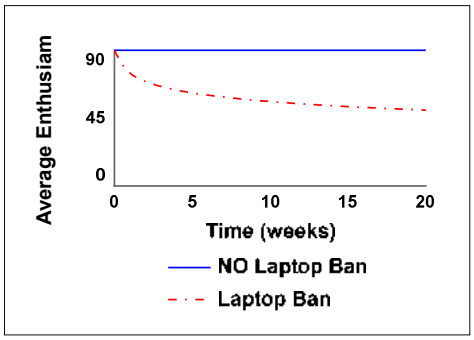
What can SDS do?



"A Co-flow for Goal-Directed Internal Change"
Gambardella, Polk, Lounsbury, Levine, System Dynamics Review (in press)

Results for Case where No SDS Interventions for Laptop Ban





Validity Checklist

Validate Variable

1. Face Validity

Correspond to something in the real world?

Subjectively represent what it is intended to in the model?

Check: Schedule Pressure

Yes. The additional work can create pressure

Schedule pressure = (Work To Do)/(normal work to do)

Check: "Enthusiasm"

Your Turn!

Validity Checklist

Validate Variable

2. Content Validity

Tap into the full range of meanings of the underlying concept?

Other dimensions?

Check: Schedule Pressure

Other possible dimensions may be at play (e.g., external product deadlines). You might need to extend the model. Yes.

Check: "Enthusiasm"

Your Turn!

Validity Checklist

Validate Variable

3. Construct Validity

Correlate appropriately with other constructs (related and unrelated)?

Check: Schedule Pressure

Correlates with burnout (+) and morale (-); and not sunspots (0).

Yes.

Check: "Enthusiasm"

Your Turn!

Validity Checklist

Validate Variable

4. Predictive Validity

Does it predict future behaviors or conditions?

Check: Schedule Pressure

Does it predict turnover?

Yes!!

Check: "Enthusiasm"

Your Turn!

Validity Checklist

Validate Variable

5. Correlational Validity

Correlate with alternate dimensions (factors) of same construct at the same time?

Check: Schedule Pressure

Schedule pressure is correlated with feeling tense, anxious, fatigued, ..

Check: "Enthusiasm"

Your Turn!

Our Validity Check List Helps

Clarify the Construct

Design and Build the Model

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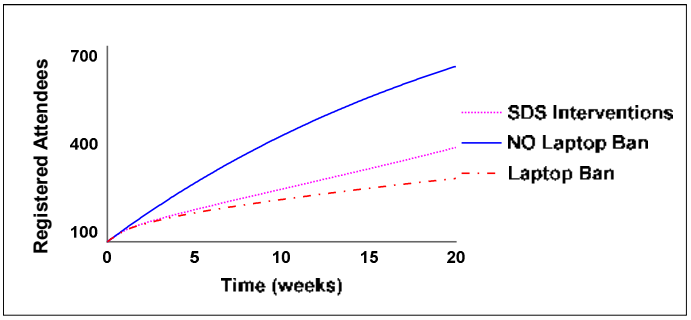
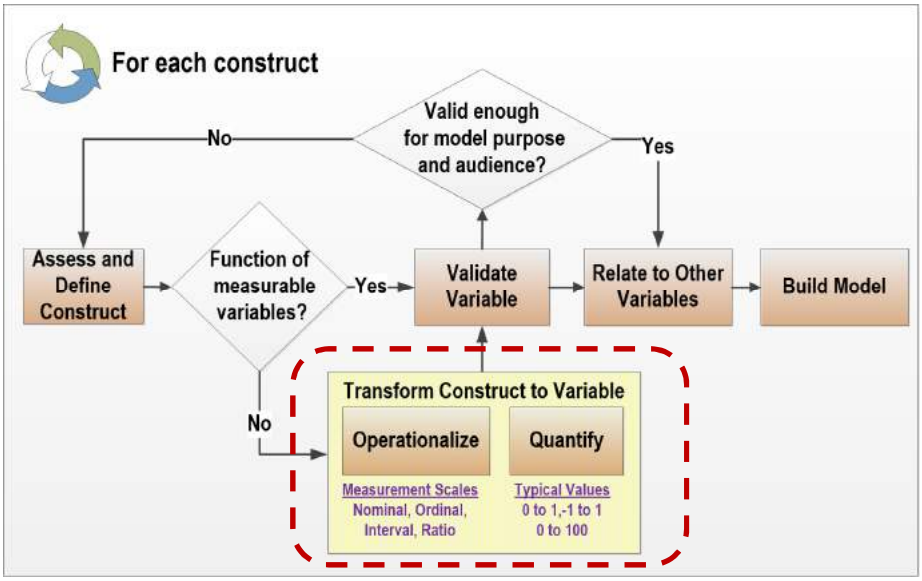
Demo

Airline Laptop Ban Co-flow Model with Intervention

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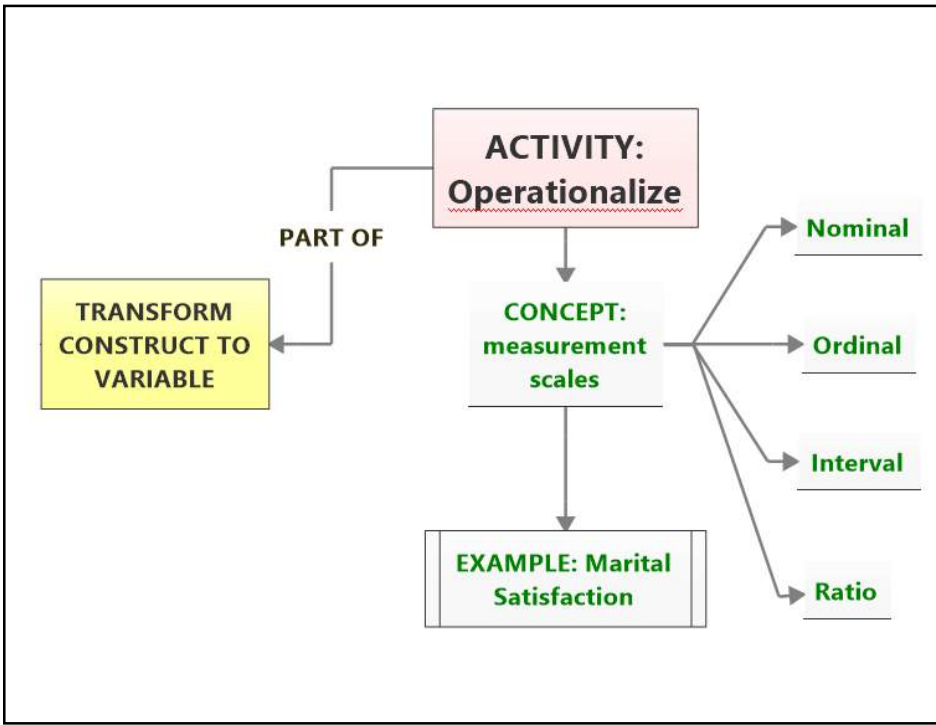

ACTIVITY: Operationalize
PART OF
TRANSFORM CONSTRUCT TO VARIABLE
CONCEPT: measurement scales
Nominal
Ordinal
Interval
Ratio
EXAMPLE: Marital Satisfaction

Measurement Scales - Nominal

Operationalize

Time	Temperature
Day	Hot
Night	Cold

Scale Features

- Mutually exclusive categories
- No ordering

Measurement Scales - Ordinal

Operationalize

Time	Temperature
Night	Cold
Dawn	Cool
Noon	Lukewarm
Afternoon	Warm
Evening	Hot

Scale Features

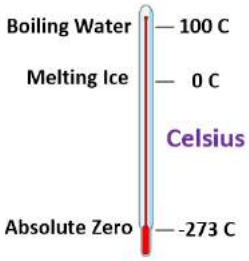
- Nominal scale features
- Indicates direction, ordering of categories

Measurement Scales - Interval

Operationalize

Time

Temperature



Scale Features

- Previous scale features
- Differences between scaled units meaningful and constant

Measurement Scales - Ratio

Operationalize

Time

Temperature

Scale Features

- Previous scale features
- Meaningful origin
- Ratio comparisons meaningful (e.g., twice the temp in K)

Marital Satisfaction - Nominal

Scale	Question	Response Categories or Assessment
Nominal	Are you satisfied with your marriage?	YES or NO
Ordinal		
Interval		
Ratio		

Marital Satisfaction - Ordinal

Scale	Question	Response Categories or Assessment
Nominal		
Ordinal	How satisfied are you with your marriage?	'Hot' 'Warm' 'Luke warm' 'Cold'
Interval		
Ratio		

Marital Satisfaction - Interval

Scale	Question	Response Categories or Assessment
Nominal		
Ordinal		
Interval	How satisfied are you with your marriage?	5=Very satisfied, 4=Somewhat satisfied, 3=Unsure, 2=Somewhat unsatisfied, 1=Very unsatisfied
Ratio		

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Marital Satisfaction - Ratio

Scale	Question	Response Categories or Assessment
Nominal		
Ordinal		
Interval		
Ratio	How satisfied is your marriage?	0 to 10

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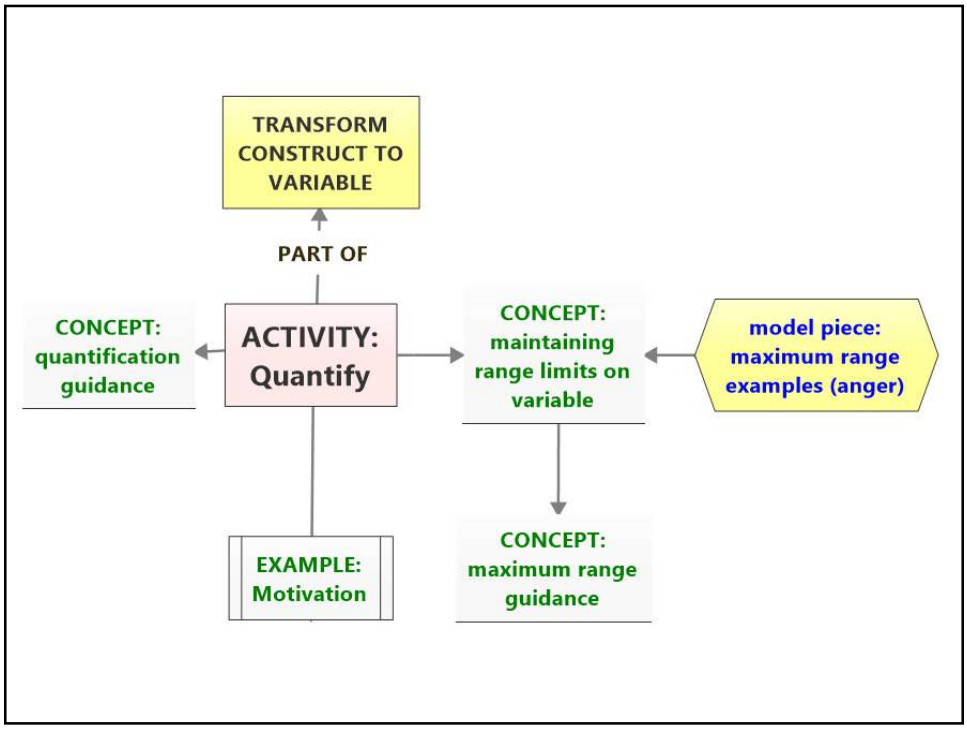
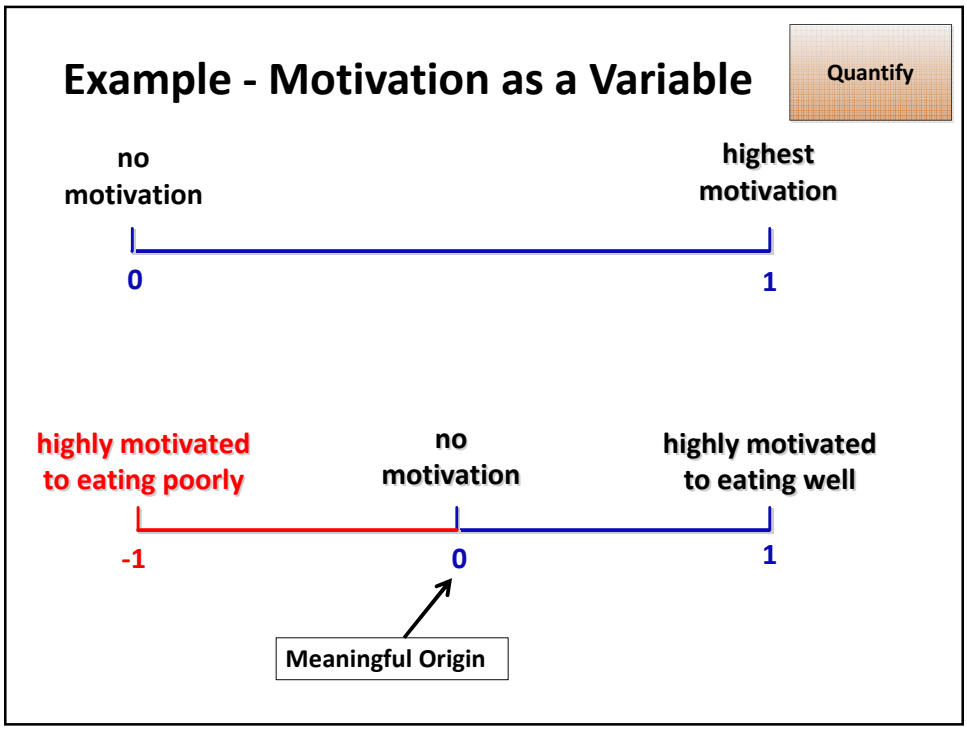

TRANSFORM CONSTRUCT TO VARIABLE
PART OF
CONCEPT: quantification guidance
ACTIVITY: Quantify
CONCEPT: maintaining range limits on variable
model piece: maximum range examples (anger)
EXAMPLE: Motivation
CONCEPT: maximum range guidance

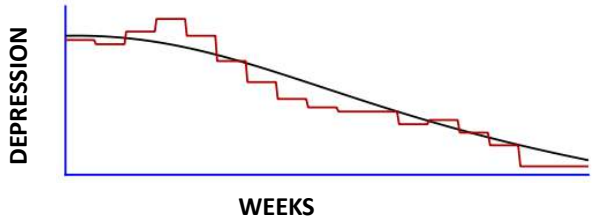

Example - Motivation as a Variable
Quantify
no motivation
highest motivation
0
1
highly motivated to eating poorly
no motivation
highly motivated to eating well
-1
0
1
Meaningful Origin

Guidance: Relating to Data

Quantify

COMPARED
If variable needs to be compared or correlated with empirical data, make it meaningful and realistic

CALIBRATE
When possible, calibrated to fit historical data



Beck Depression Scale:

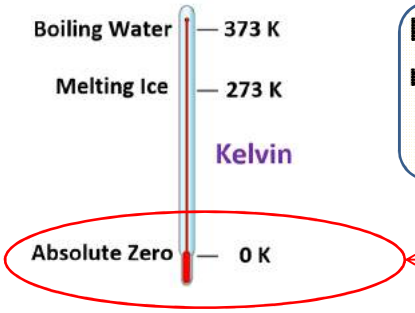
Range 0 – 63

- <10 → no or minimal depression
- 10 to 18 → mild-to-moderate depression
- 19 to 29 → moderate-to-severe depression
- 30+ →severe depression

Grid-Enabled Measures (GEM) Database

Guidance: Apply a Ratio Scale if Possible

Quantify



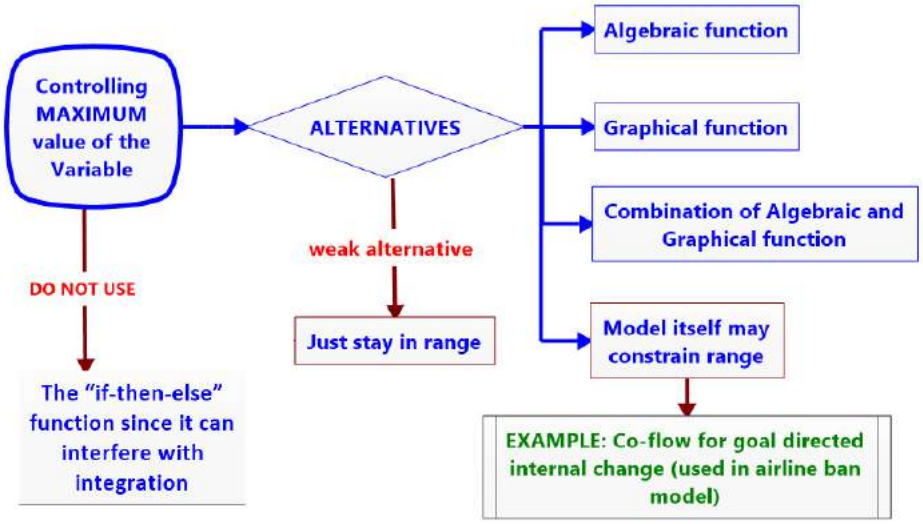
Differential equations require ratio scales

$$\frac{\partial T(x,t)}{\partial t} = \kappa \frac{\partial^2 T(x,t)}{\partial x^2}$$

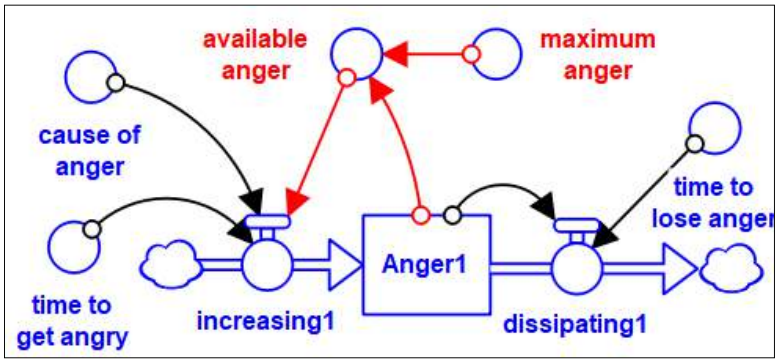
Meaningful origin

If a variable is on a ratio scale the range of the scale does not matter (e.g., -1 to 1, 0 to 100, 0 to 6)

Guidance: Controlling the Variable's Maximum

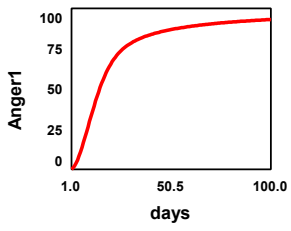


Algebraic Function Limits Upper Range



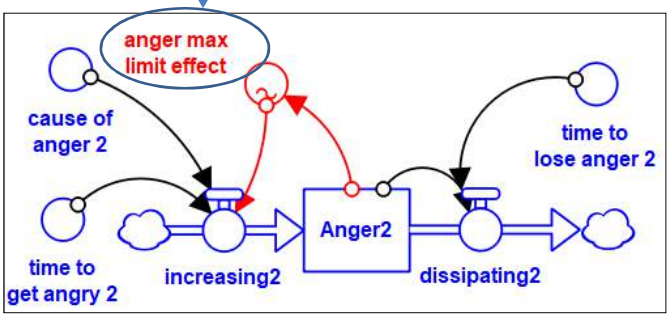
increasing1 = (cause of anger *available anger)/(time to get angry)

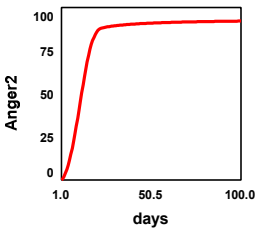
available anger = (maximum anger – Anger1)/(maximum anger)



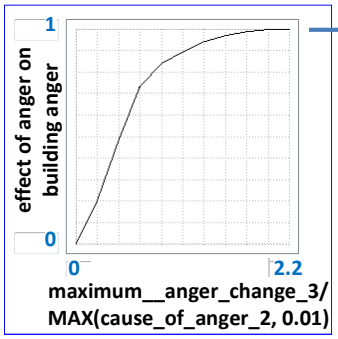
Graphical Function Limits Upper Range

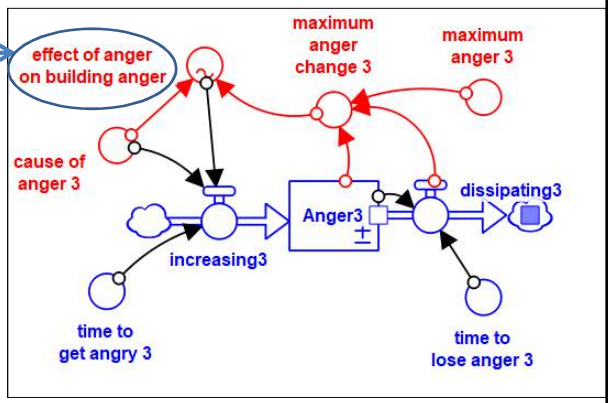
increasing2 =
(cause of anger *anger max limit effect)
/(time to get angry)



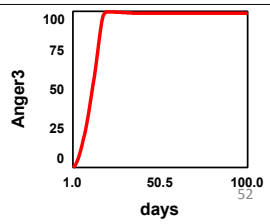


Algebraic & Graphical Function Limits Upper Range

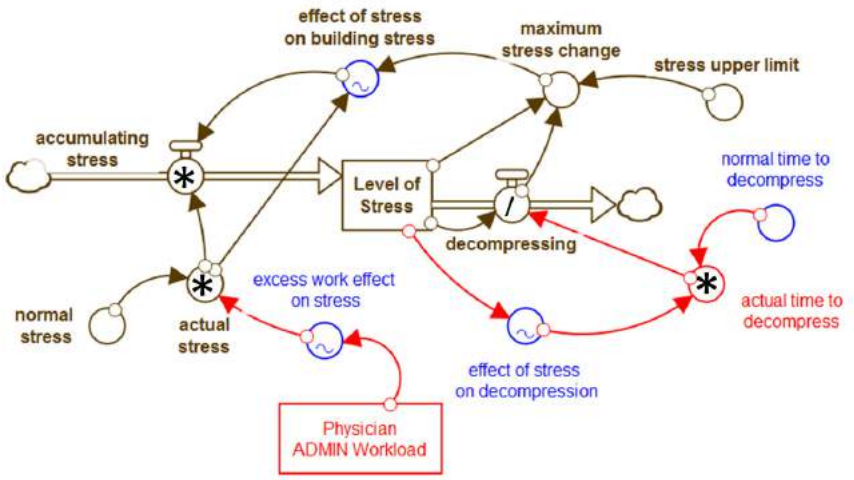




Maximum anger change 3 =
(maximum anger 3) - Anger3 + dissipating3



Another Example: Stress



maximum stress change = (stress_upper_limit - Level_of_Stress) + decompressing

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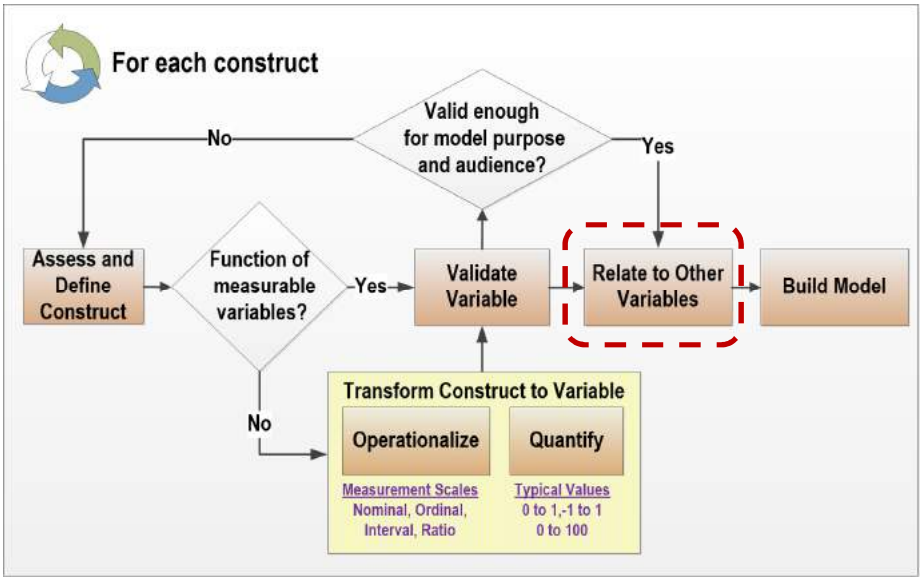
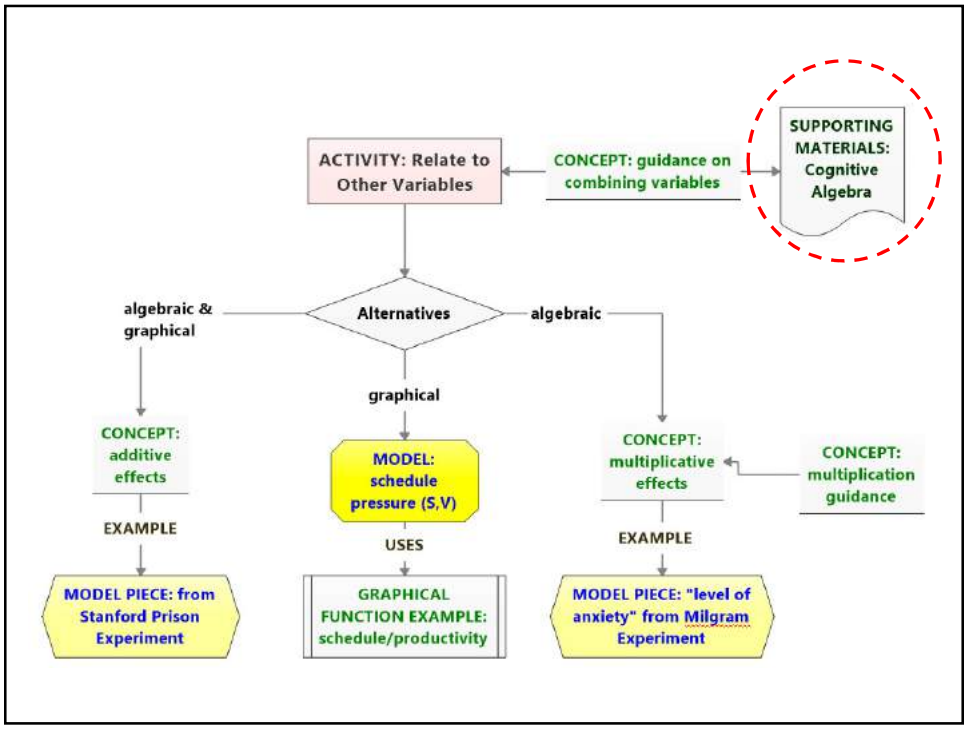
SD modeling is learning by doing. It is learning by being surprised by the mistakes one makes.

Jay Forrester

All models are wrong but some are useful.

George Box

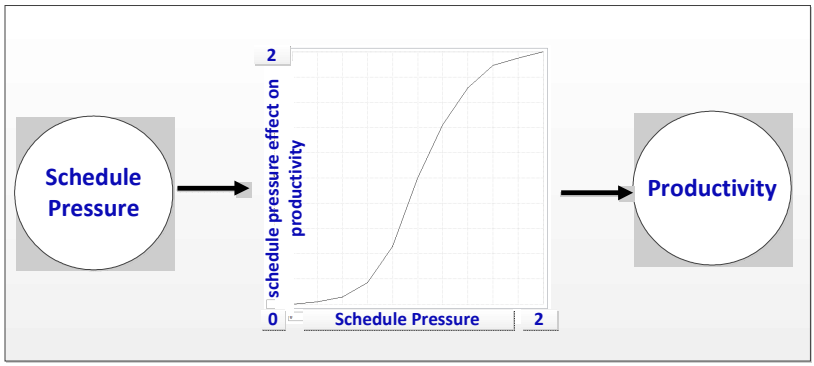




Guidance: Using Graphical Functions

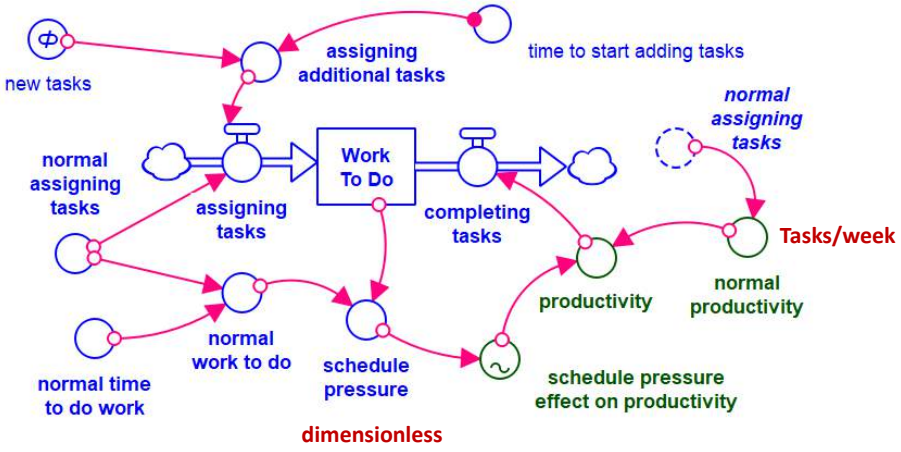
Relate to Other Variables

Use intermediate graphical functions if needed when relating one variable to another



Productivity = "schedule pressure effect on productivity"*normal productivity

Example - Graphical Functions



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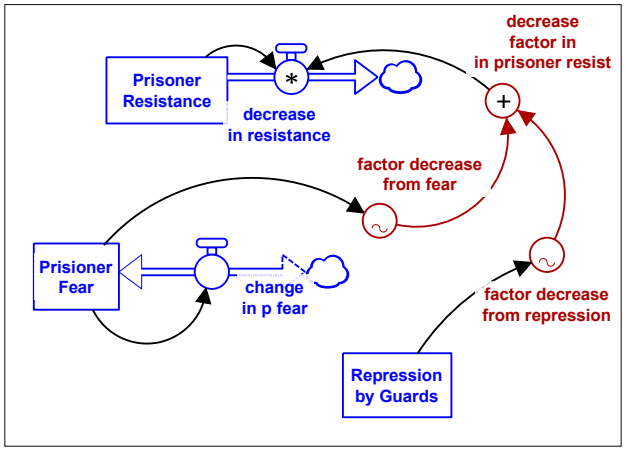
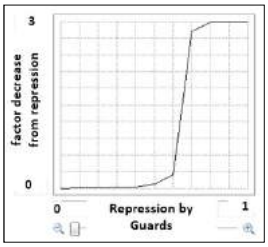
Example – Additive & Graphical Effects

Relate to Other Variables

Decrease factor in prisoner resistance =
(factor decrease from fear) + (factor decrease from repression)



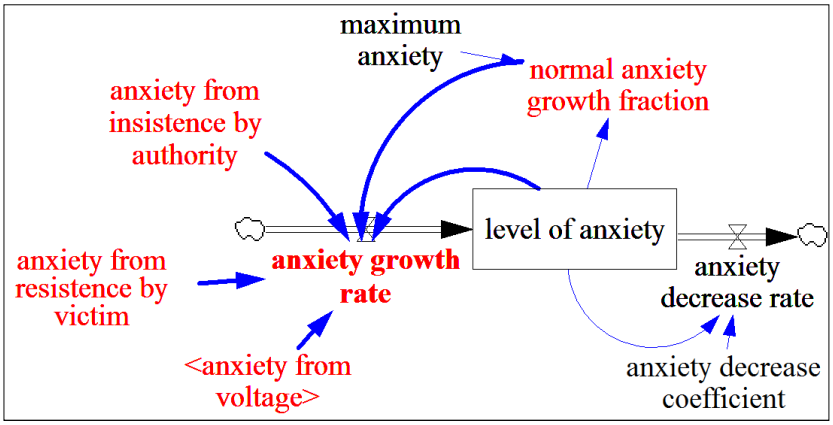


Stanford Prisoner Model segment (adapted from Doyle, Saeed, Skorinko, 2009)

Example: Multiplicative Effects

Relate to Other Variables

anxiety growth rate = normal anxiety growth fraction*level of anxiety*anxiety from insistence by authority*anxiety from resistance by victim *anxiety from voltage



Milgram Experiment segment (adapted from Doyle, Saeed, Skorinko, 2009)

Multiplication Guidance

Relate to Other Variables

total effect = (product of multiple variables)

Use zero for a variable only if its absence cancels the total effect

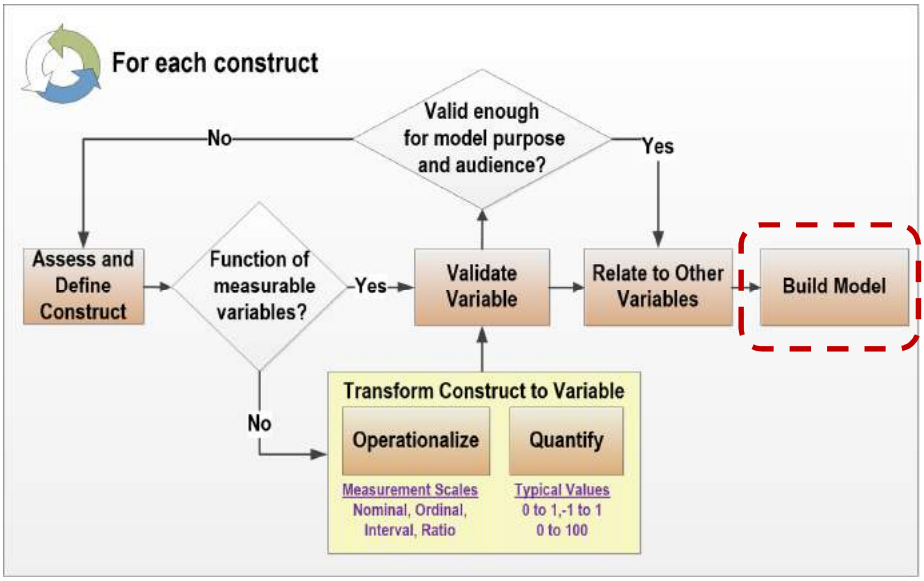
Multiplying two variables less than 1 yields a smaller result

A variable itself could be a product

EXAMPLE: Motivation = (effect of winning awards)*(normal motivation)

When possible define the influence of a variable as a ratio

EXAMPLE: Motivation factor = (current motivation)/(maximum motivation)


For each construct
Valid enough for model purpose and audience?
No
Yes
Assess and Define Construct
Function of measurable variables?
Yes
No
Validate Variable
Relate to Other Variables
Build Model
Transform Construct to Variable
Operationalize
Quantify
Measurement Scales
Nominal, Ordinal, Interval, Ratio
Typical Values
0 to 1,-1 to 1
0 to 100

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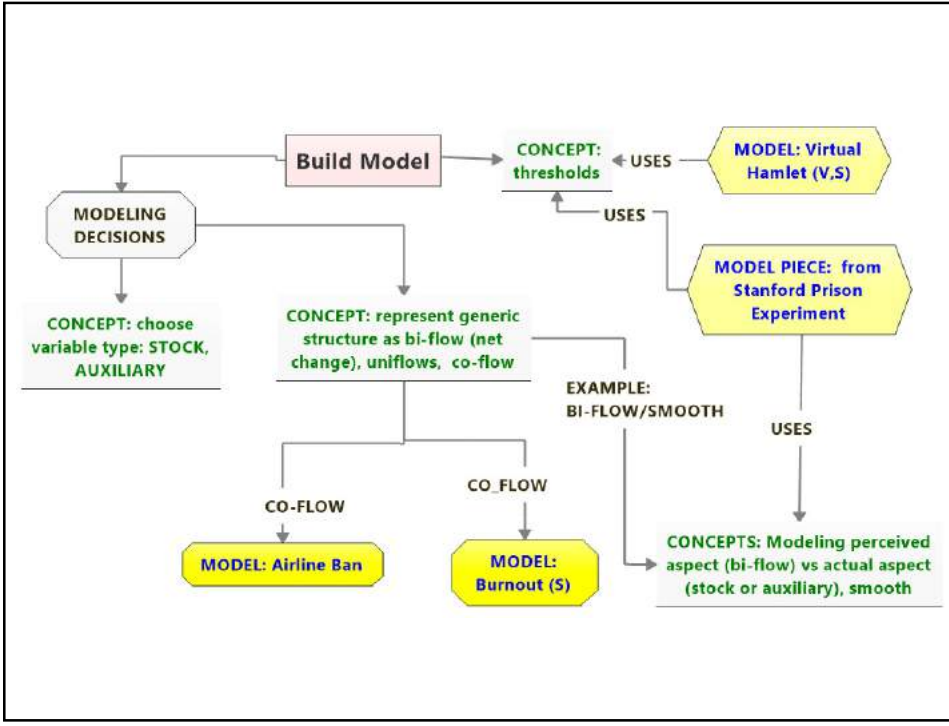
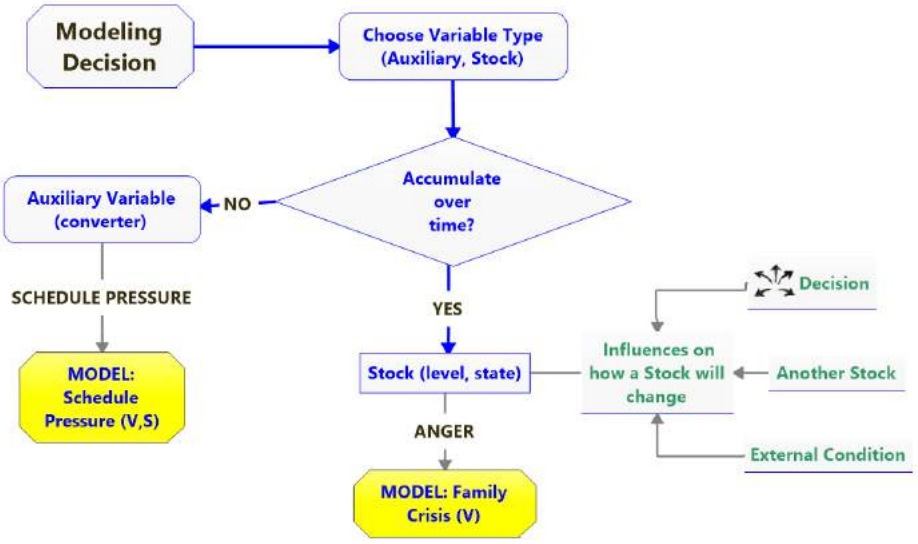
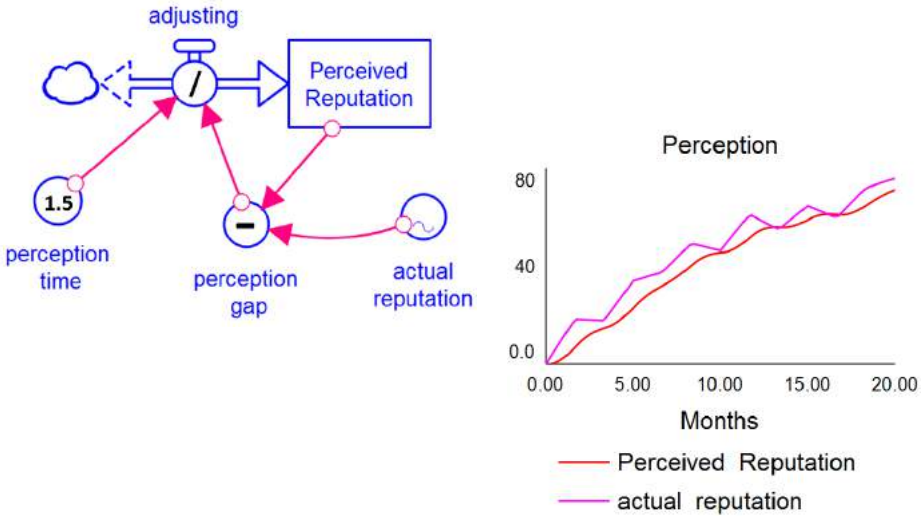

Build Model
CONCEPT: thresholds
USES
MODEL: Virtual Hamlet (V,S)
MODELING DECISIONS
USES
MODEL PIECE: from Stanford Prison Experiment
CONCEPT: choose variable type: STOCK, AUXILIARY
CONCEPT: represent generic structure as bi-flow (net change), uniflows, co-flow
EXAMPLE: BI-FLOW/SMOOTH
USES
CO-FLOW
CO_FLOW
MODEL: Airline Ban
MODEL: Burnout (S)
CONCEPTS: Modeling perceived aspect (bi-flow) vs actual aspect (stock or auxiliary), smooth

Build Model



PERCEPTION: Smooth

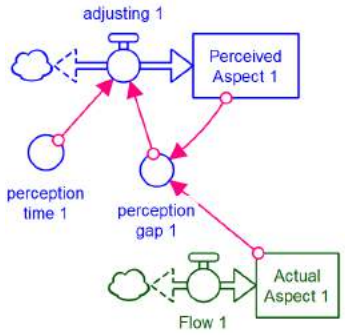
Build Model

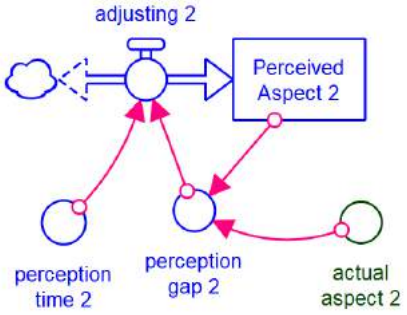


Perception – Stock vs Auxiliary

Build Model

Actual Aspect Could be a Stock

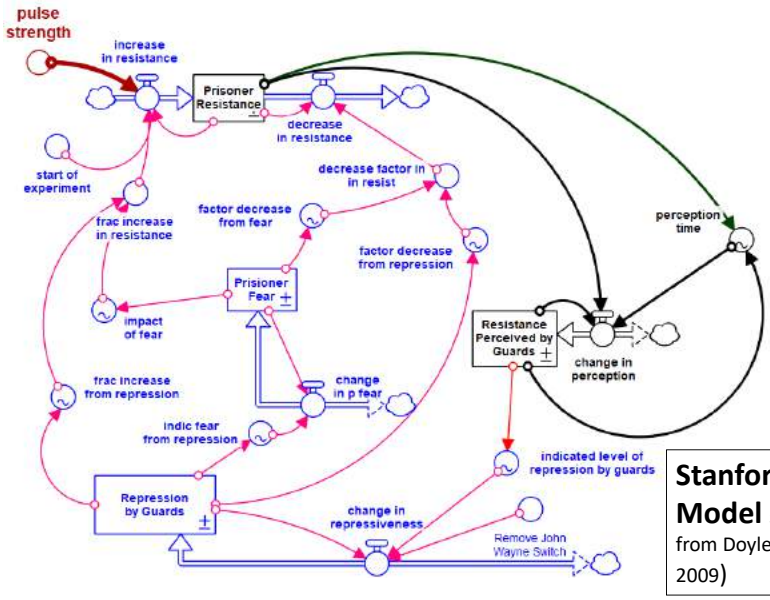




Stanford Prison Model is an Example

PERCEPTION: Actual Aspect = "Stock (Prisoner Resistance)"

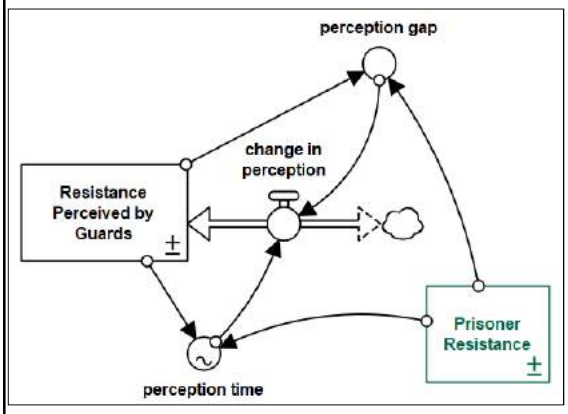
Build Model



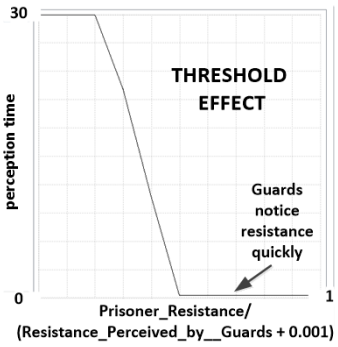
Stanford Prisoner Model segment (adapted from Doyle, Saeed, Skorinko, 2009)

THRESHOLD EFFECT
Resistance Perceived by Guards

Build Model

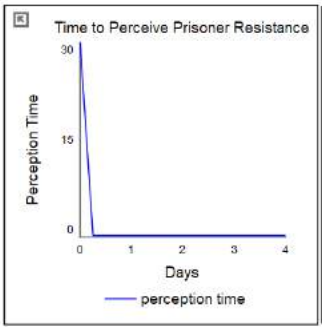


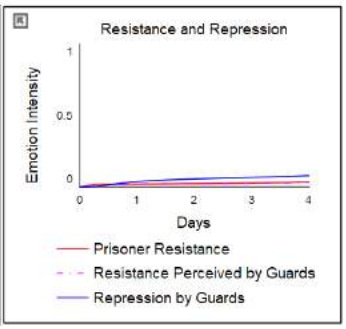
Low levels of prisoner resistance will go undetected and high levels will be quickly detected.



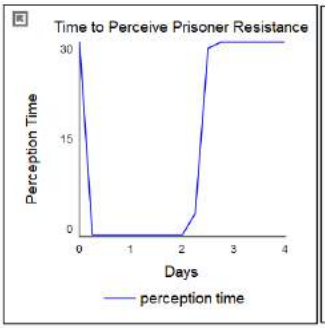
Change in perception = (Prisoner_Resistance - Resistance_Perceived_by_Guards)/ (perception_time)

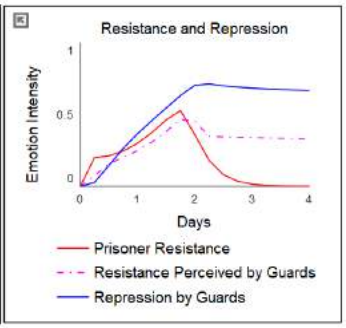
Prisoners Offer Slight Initial Resistance at time = 0



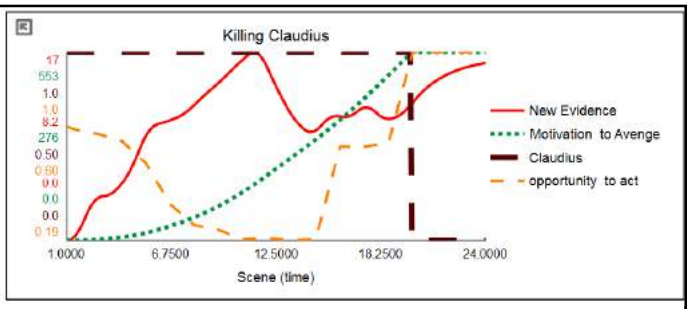


Prisoners Offer Significant Initial Resistance at time = 0

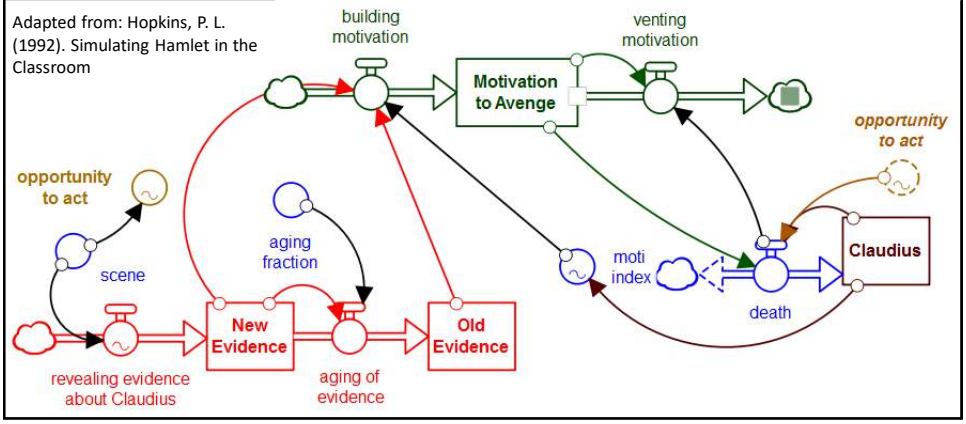




Hamlet – Opportunity, Motivation, Revenge

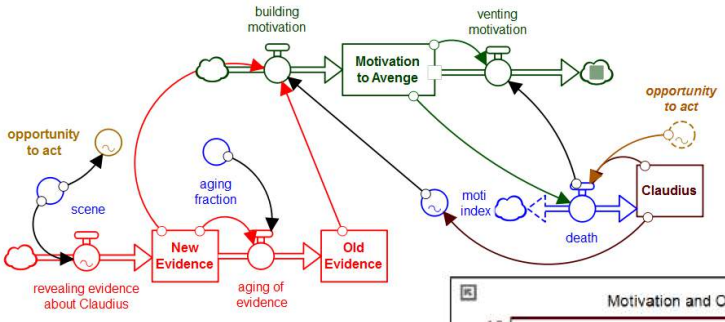


Adapted from: Hopkins, P. L. (1992). Simulating Hamlet in the Classroom

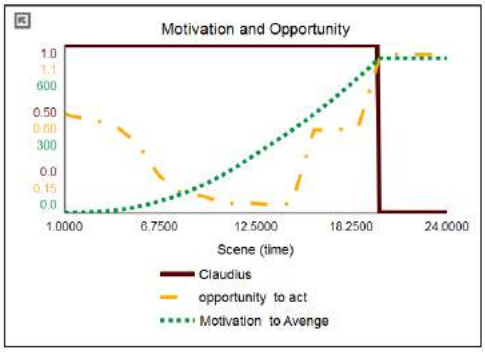


THRESHOLD EFFECT: Killing Claudius

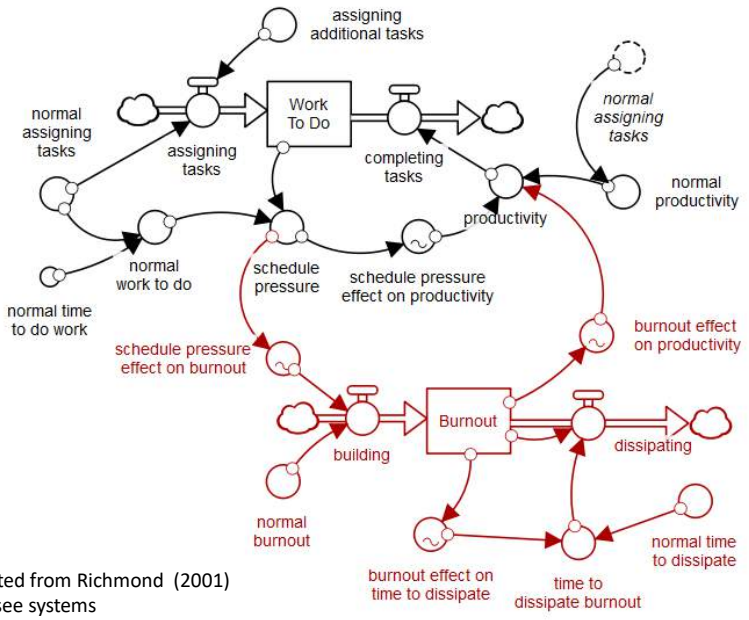
Build Model



death =
IF ((Motivation__to_Avenge >= 95) AND (opportunity__to_act >= 0.95))
THEN (-Claudius/**DT**)
ELSE 0



Coflow – Schedule Burnout



Adapted from Richmond (2001) and isee systems

EXERCISE: "Ill-Funded Police Pensions Put Cities in Bind"

Wall St Journal, July 5, 2017

"Municipalities that try cutting retirement plans face pushback both from the officers, some of whom quit, and from a pro-police public."

- Suppose the city want to retain policemen
- Model current problem (stock and flow sketch)
- Just apply <u>one or two</u> things you have learned today
- Work in small groups

RESOURCES

Supporting Material

- Annotated Bibliography of Psychological and Sociological Modeling
- Advanced Topic - Cognitive Algebra
- Example Models
- Upcoming Chapter
  - Modeling Psychological and Sociological Dynamics (Lounsbury, Gambardella)
  - System Dynamics volume **Encyclopedia of Complexity & Systems Science** (Brian Dangerfield, Volume Editor), Springer

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