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

Modeling Psychological and Sociological Dynamics

Methods and Applications

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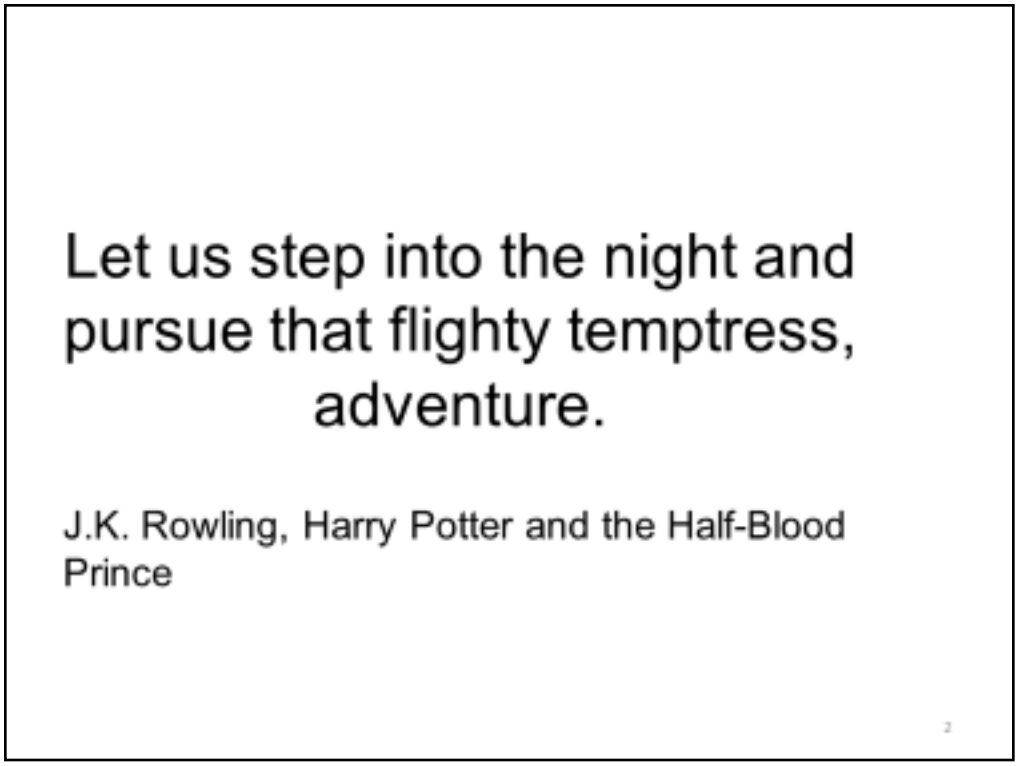
FRAMES:
(1) We will discuss models and primarily focus on the psychological and sociological variables.
(2) Some slides we may just mention and skip.



We like to thing of our journey modeling with psychological and sociological variables as an adventure…

Don't read the slide

1 – Preliminaries

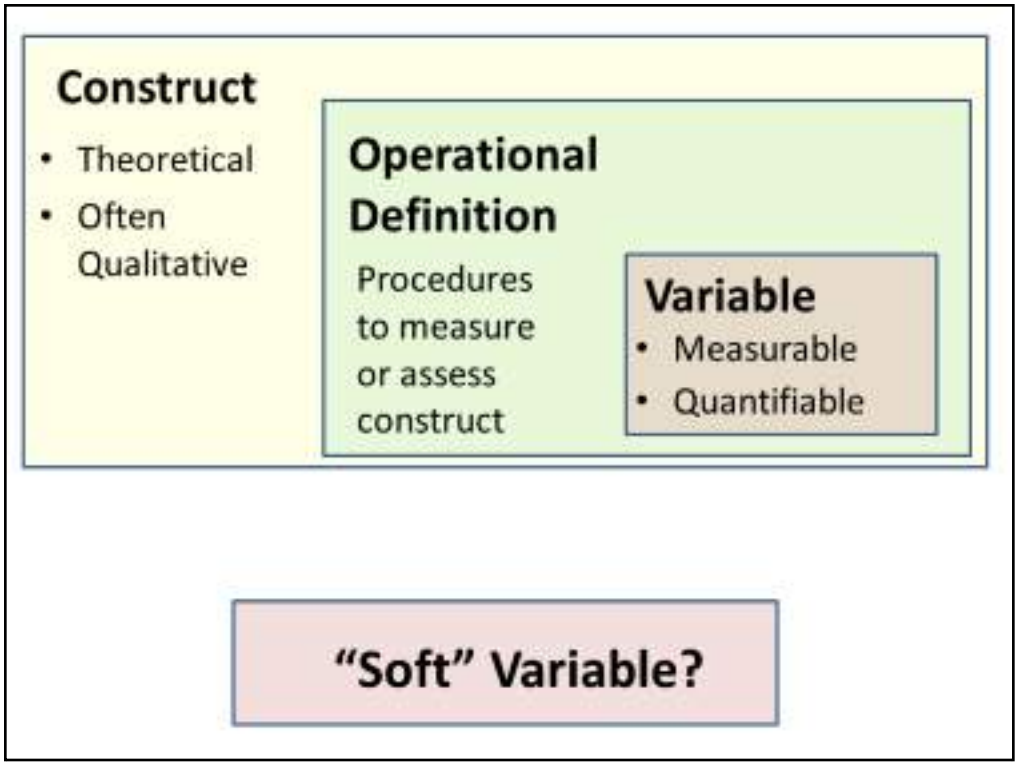
2 – Modeling Approach

3 – Defining and Transforming "Soft Constructs" to Variables

4 – Modeling Building Mechanics

Ask audience this question. Helps us get a idea about people's terms and beliefs

Have you had in any in your models.



Construct. Broad concepts or topics of study.

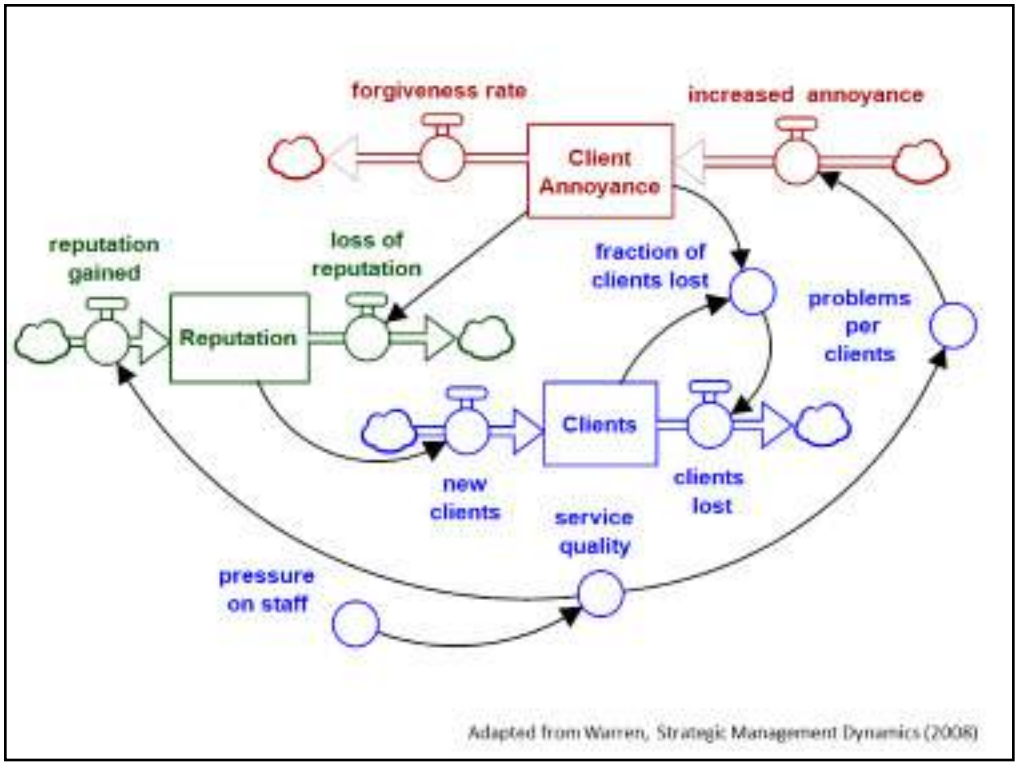
Abstract. Not directly observable. May be complex (have multiple parts).
EXAMPLES: love, aggression, intelligence, life satisfaction
Conceptual Definition. Provides meaning in abstract or theoretical terms
Operational Definition. Defines a construct by specifying the procedures used to measure or assess a construct: provide a clear definition or designate a particular measurement instrument to represent the concept [operational definitions may not always be good .. they may not accurately capture the intended construct (i.e., lack validity). Burnout can be made measurable.

Variable. When we operationalize a concept, we are creating a variable. Variable = any characteristics that varies (i.e., has at least two values)

Soft" Variables - "soft", principally because they are connected with social sciences NOT because they are intrinsically unmeasurable. Address misconceptions that come from the metaphors we use – "soft" vs "hard."

"stock and flow." The term flow presupposes some material moving. Many soft variables are expresses as changes in state – some things increase the state, other things can decrease it (assumes ratio scale). Perhaps "level/state and rate of change" would be better. The language we use affects how we think about things.

When you operationalize you make it quantitative.



The Dynamics of Reputation (Physician review example – hiring a company to address online bad reviews)

Story to introduce the model: Went to get a car stereo from a dealer with a good online reputation. I waited in the showroom for 15 minutes, saw some employees who saw me, and no one came. My annoyance was high, and their reputation plummeted in my eyes. I left and went some where else with a vastly different experience. "The Customer is Bothering Me" Shelle Rose Charvet-

Sketch of a typical business example . Simple partial model of the dynamics of reputation. Possible questions to participants:
Where are the soft variables? Should we include them?

Two soft variables. **They are ubiquitous and important.** Using a particular structure to represent soft variables. Other things driving this and are not shown. Reputation can ebb and flow. Client Annoyance is an attribute of clients, coflow.

This slide helps define the terms through examples: psychological (client annoyance), sociological (reputation, pressure on staff), soft or intangible (client annoyance, reputation, service quality).

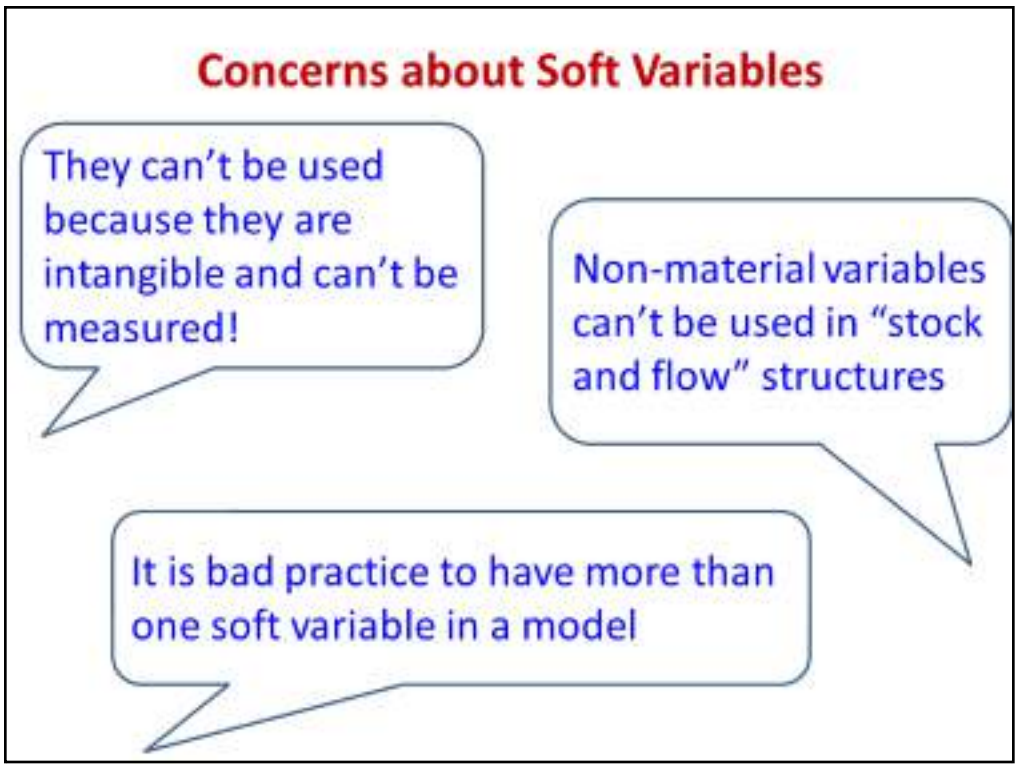
(Ralph) Discuss "pressure on staff" which is defined to mean [also ratio]
= amount of work to be done / capacity of staff to do the work -- defined in terms of hard variables. So we really have a hard variable in the model. Just an assumption. You might have a proxy for actual variable. How accurate is it? Do correlational analysis. Look at sub-concepts that go with it (e.g., using factor analysis or cluster analysis –IQ has a variety of sub-scales). Are you measuring the outside forces or the perceptions of the people? They could be some processes that might be aggregated because of the pressure. The pressure could be quite high and the people are resisting it.

We want to find out why people are here and what they expect to gain from these sessions.

Ask for quick responses (5 min)

- What disciplines are represented here today?
- Who has used soft variables, intangibles, psychological or sociological variables in models?
- Were they useful?
- What do you expect from this workshop?

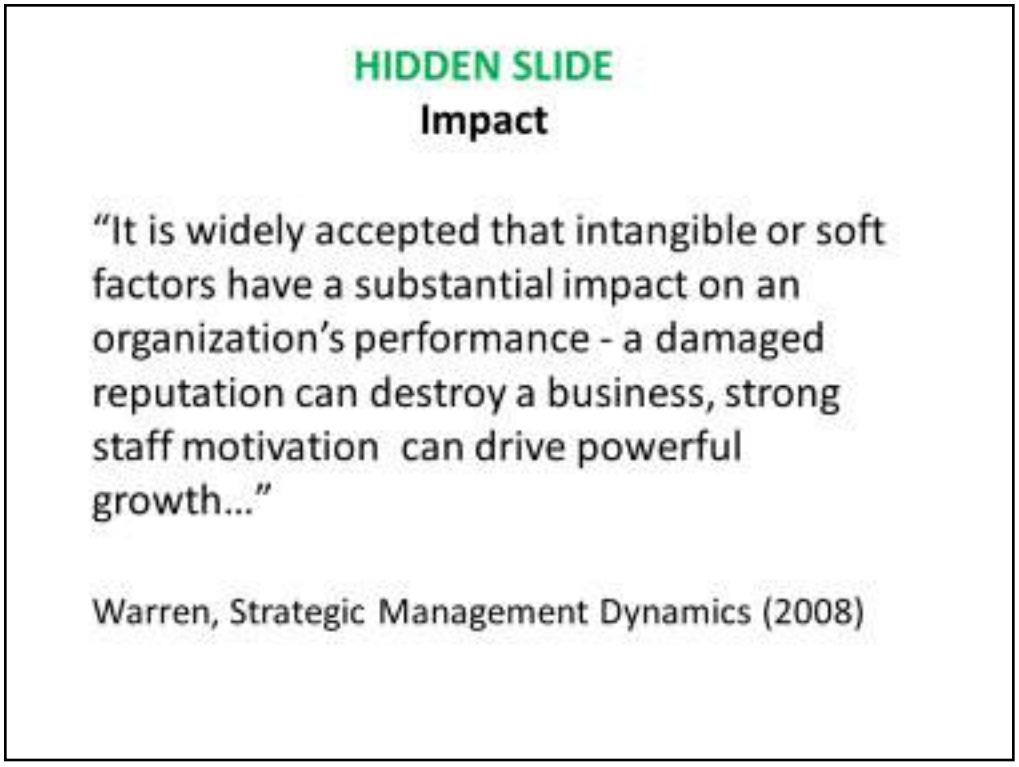
What disciplines do they come from? This contributes to how they think, terminology and the type of models they will build.



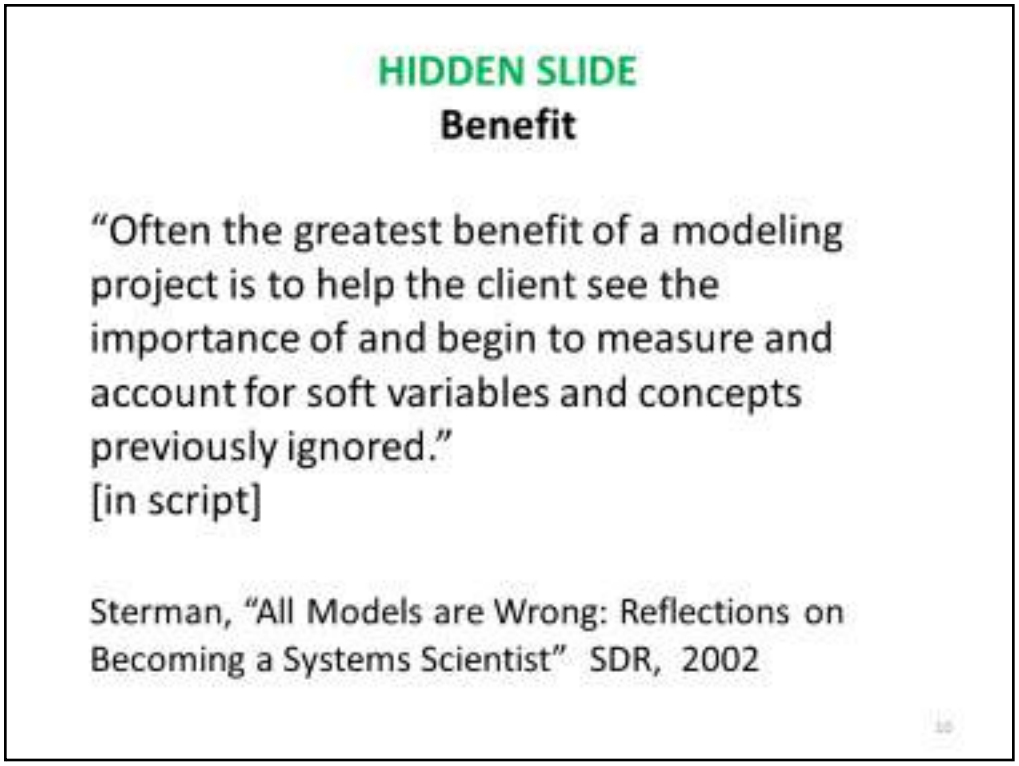
Paraphrased concerns. Later discuss more general terminology: stock and flow, state and rate (of change). Vensim calls it a box variable and rate, Stella/Ithink calls it stock and flow.

ASK "what do you think"

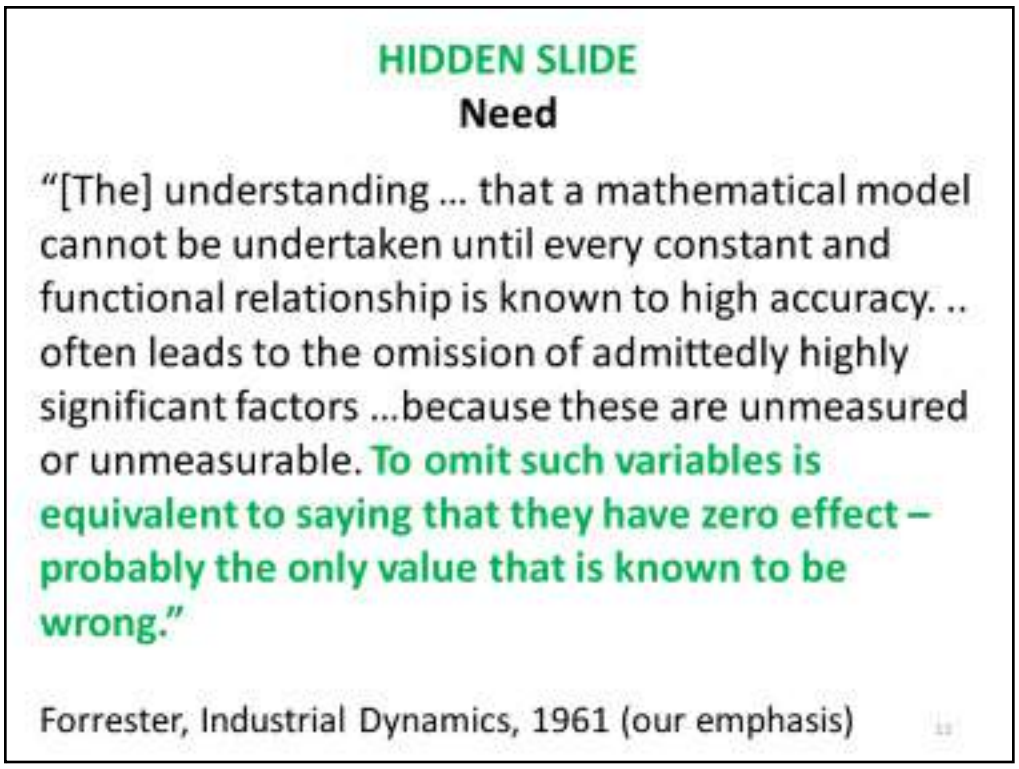
The last one implies. SD can't be effective in psychology.
Third. It depends on the problem



Warren, Strategic Management Dynamics (2008), page 576



Sterman, "All Models are Wrong…" SDR 2002, page 524



Forrester, Industrial Dynamics, 1961 page 57

More of the quote:

"There seems to be a *general* understanding … that a mathematical model cannot be undertaken until every constant and functional relationship is known to high accuracy. This often leads to the omission of admittedly highly significant factors (most of the "intangible" influences on decisions) because these are unmeasured or unmeasurable. **To omit such variables is equivalent to saying that they have zero effect – probably the only value that is known to be wrong."**

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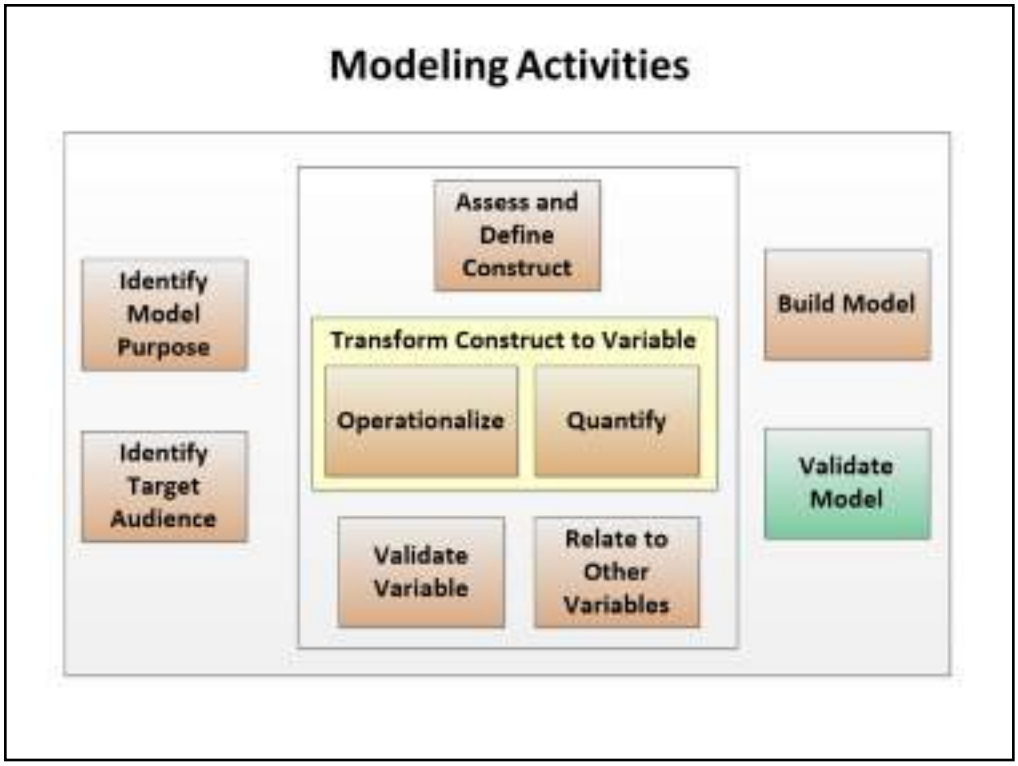


Show whole slide. Mention what we will cover and not cover (Validate Model)

- **Construct** refers to a psychological or sociological concept
- **Operationalize** = transforming "construct" to "measurable variable"

Discuss how we put it together. Mention other references.

MIDDLE BOXES:
SD Applied to Psychological and Social Problems, Levine
Defining, sociological concepts as variables for SD modeling, Jacobsen and Bronson
Using human judgement in SD models of Social Systems, Nuthmann

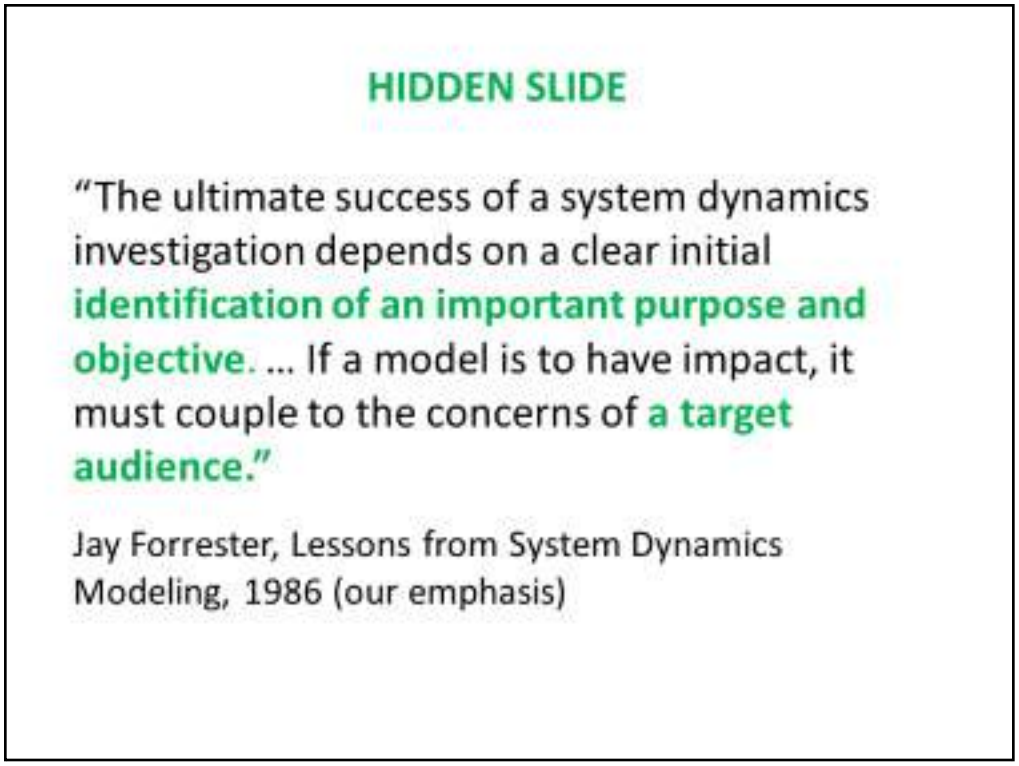
OVERALL
Richardson, Sterman (and many others) – discussions about SD modeling

Always start by Identifying model purpose (a problem). We want it to be meaningful for intended audience. At end is building and validating. And in the middle - . Our framework for doing good system dynamics. Tried to synthesize modeling. We found more about ends than what's in the middle.

Represents structure of our approach and structure our workshop

An approach for incorporating psychological and sociological variables. Come up with real models. Where do you go for knowledge (forester triangle)

Purpose – identify what processes, and what are the most (can measure most anything)



Forrester, J. W. (1986). Lessons from System Dynamics Modeling. Proceedings of the 1986 International Conference of the System Dynamics Society: System Dynamics: On the Move. J. Aracil, J. A. D. Machuca and M. Karsky. Sevilla, Spain, International System Dynamics Society: 1.

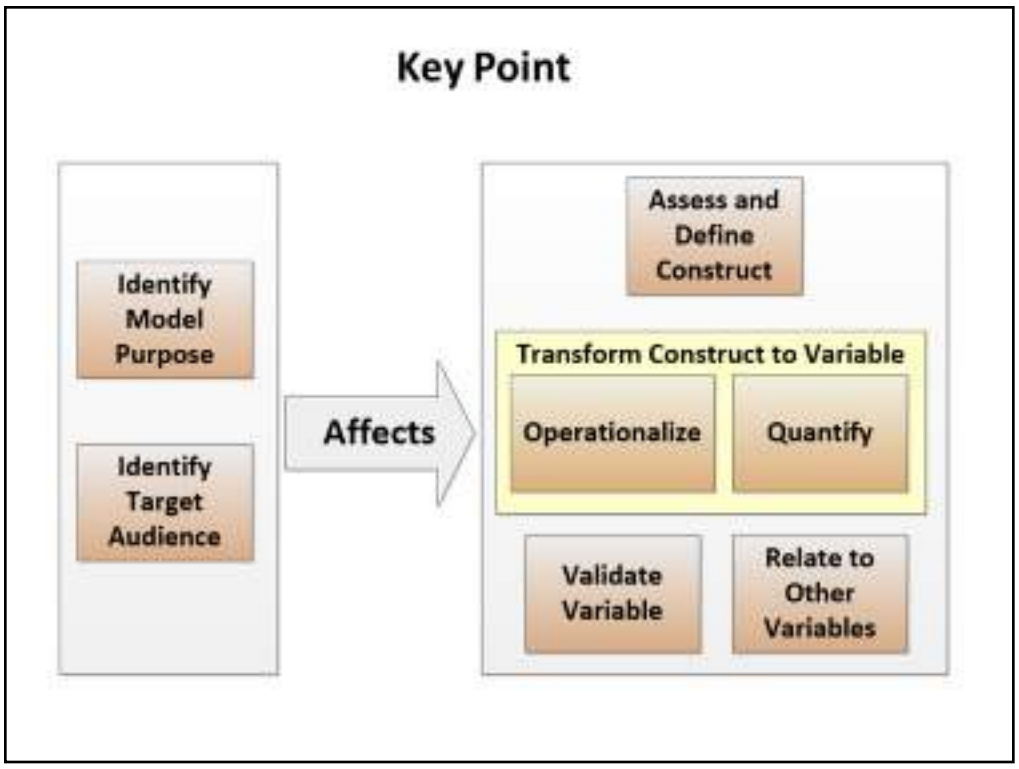
More of the quote:

The ultimate success of a system dynamics investigation depends on a clear initial identification of an important purpose and objective. ...

In general, influential system dynamics projects are those that change the way people think about a system ...

Changing and unifying viewpoints means that the relevant mental models are being altered.

But whose mental models are to be influenced? If a model is to have impact, it must couple to the concerns of a target audience. Successful modeling should start by identifying the target audience for the model.:

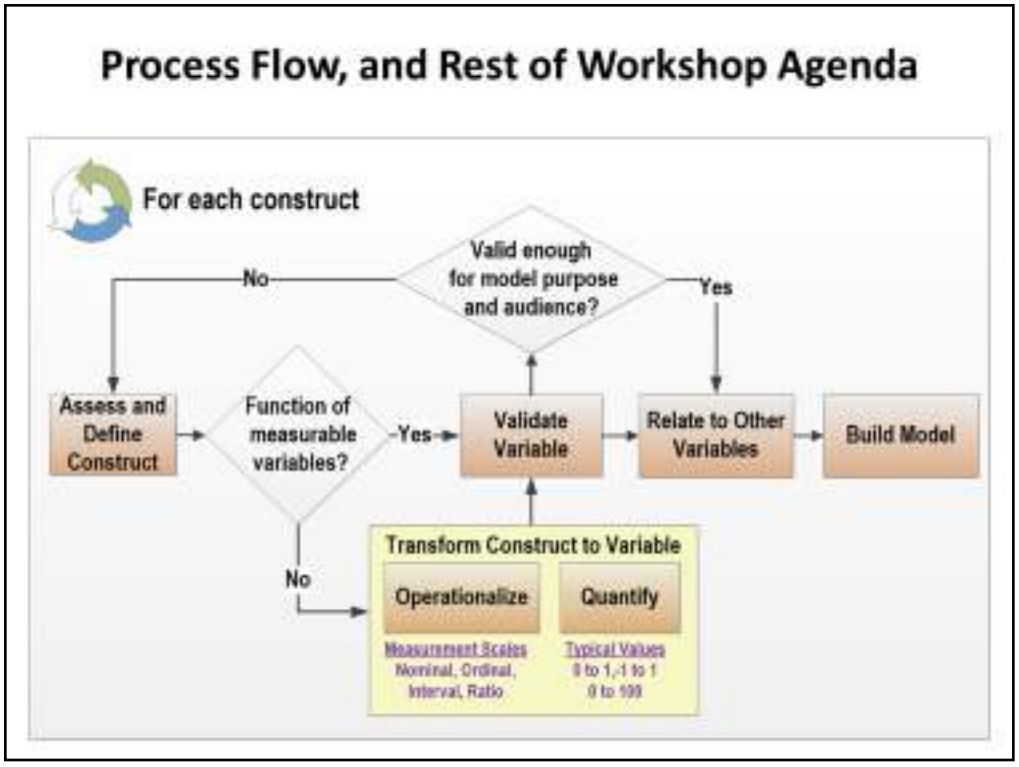


Purpose is intended target audience(s)

Mention - Forrester "Students should also realize that there is no possible proof of the validity of any model, whether they are mental or computer models. Models are to be judged by their comparative usefulness. Assumptions about structure and policies should be compared with any available information. Computer simulation results should be compared with behavior in the real system being represented. Discrepancies lead to improving both mental and computer models."

MODEL PURPOSE(S)

- Modeling psychological and sociological theories
  (Modeling theories in the social sciences and "modeling a problem" overlap. ".. A theory is the general statement about the relationship between two or more variables." Pelham, B. W., & Blanton, H. (2007). Conducting research in psychology : measuring the weight of smoke (3rd ed.). Australia ; Belmont, CA: Thomson Wadsworth., page 29}
- Modeling a problem or situation
- Teaching
- Coaching
- Explore
- Gain insight
- Enforce precision in thinking
- Predict (patterns)
- Make decisions
- Clarify thinking
- Gain understanding
- Promote common group understanding
- Be surprised!



The decision points are part of the previous activity, e.g., "Function of measurable variables" is in the activity "Assess and Define Construct." (this diagram type is part of BPMN – business process and modeling language)

Make the range meaningful (e.g., expressing the variable as a fraction – as percentages or probabilities of occurrence)
Create operational definition if variable to be compared with experimental data
Decide whether to use variable or its correlate with hard variables

Transform construct to variable – is there a valid scale? For burnout there are two or three scales in the literature. Just look at indicators of burnout process – use a pattern or one construct. Where in that multi-dim space is where burnout occurs (trajectories). Plan approach and describe constructs.

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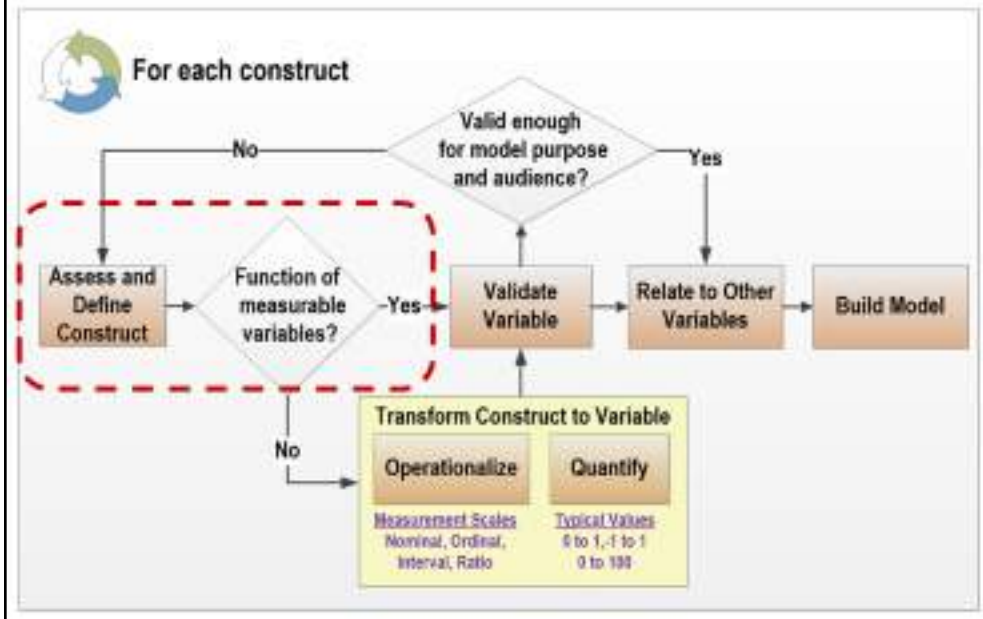
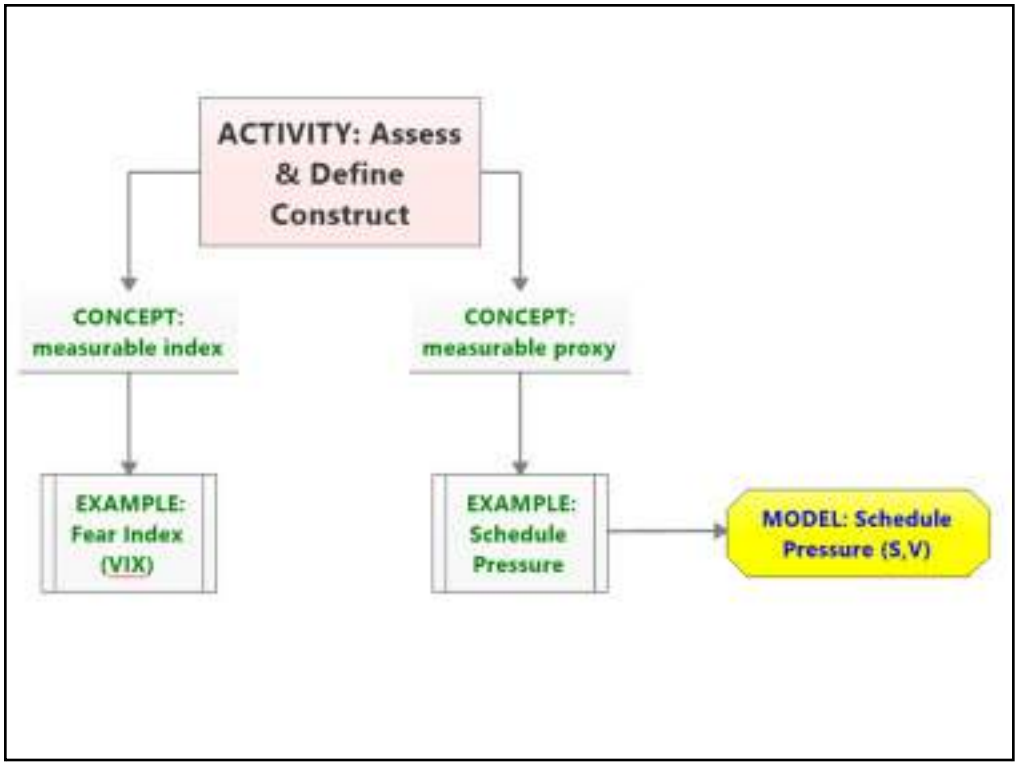
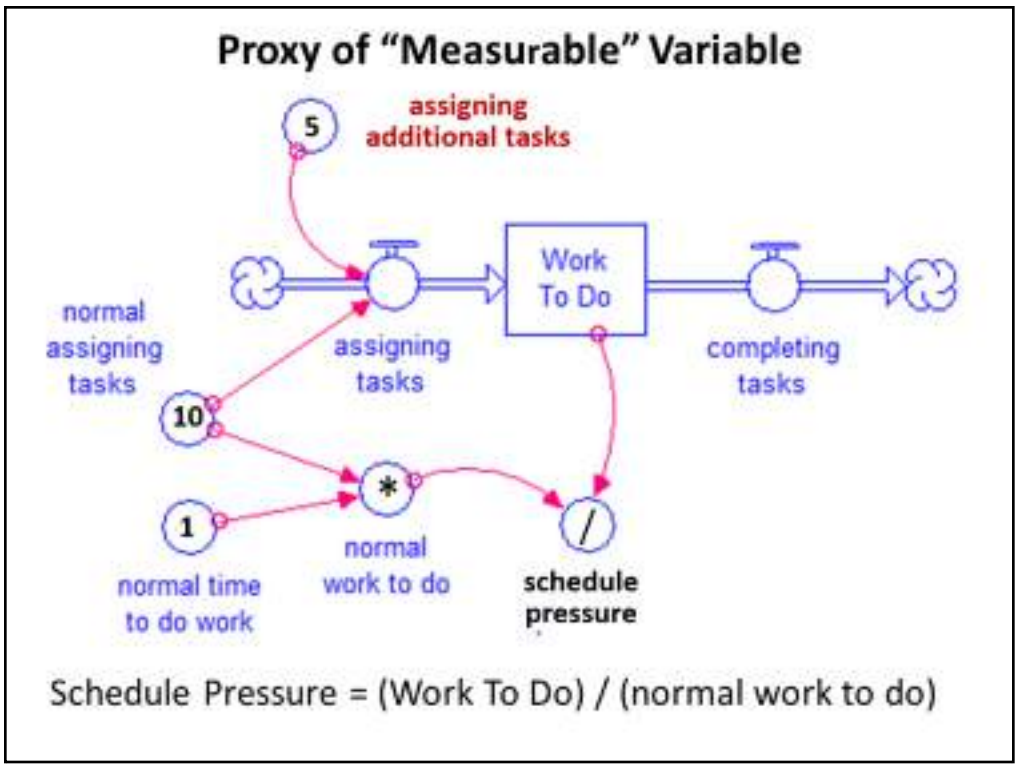
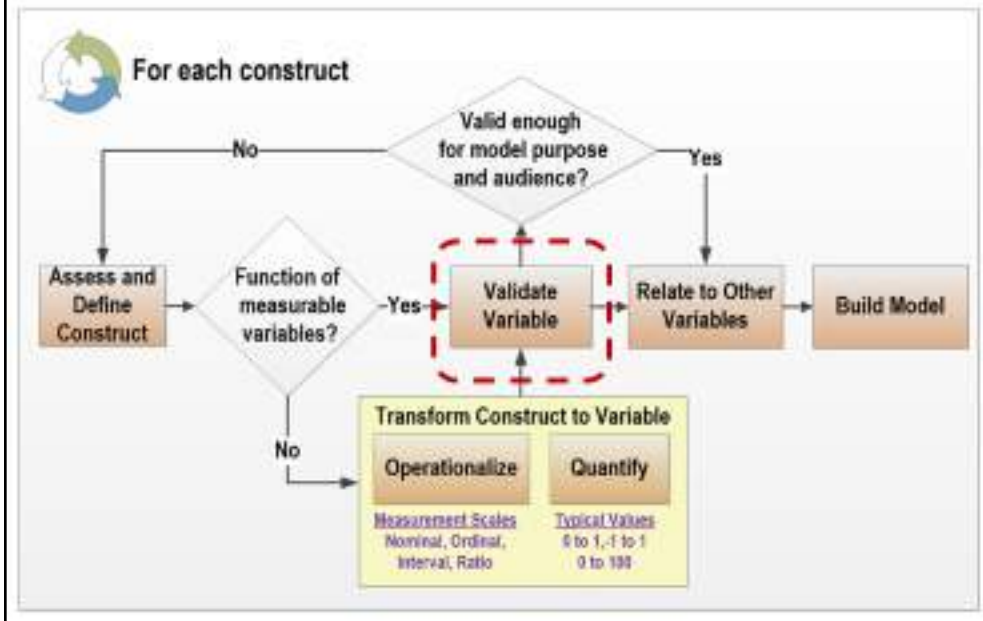

For each construct
Valid enough for model purpose and audience?
No
Yes
Assess and Define Construct
Function of measurable variables?
Yes
Validate Variable
Relate to Other Variables
Build Model
No
Transform Construct to Variable
Operationalize
Quantify
Measurement Scales
Nominal, Ordinal, Interval, Ratio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


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



This computed ratio is a proxy for schedule pressure since, for example, it misses extreme situations

The ratio is a proxy for schedule pressure. The naming of variables that define your construct should be meaningful to your target audience – you might use "morale" instead of burnout.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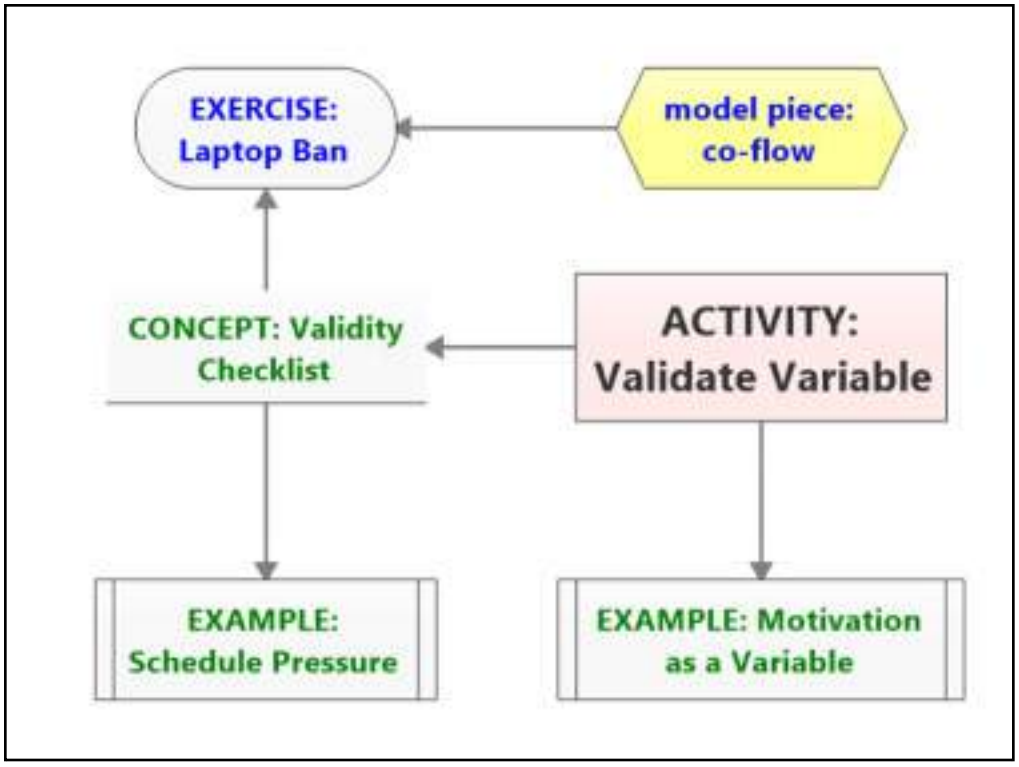
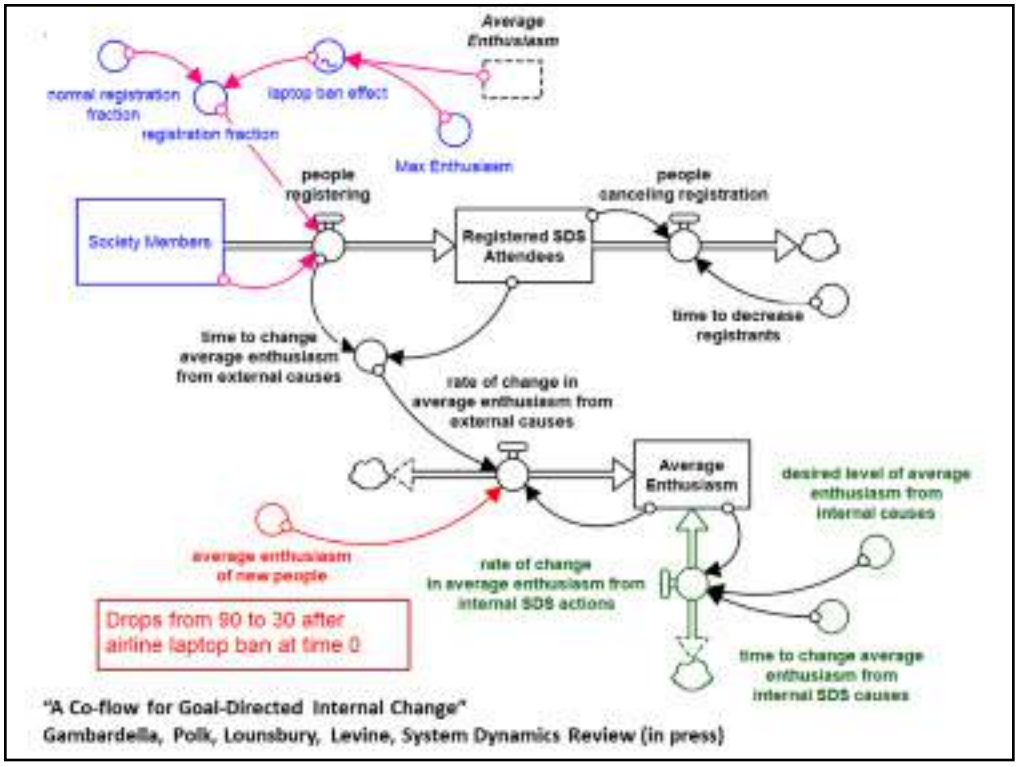
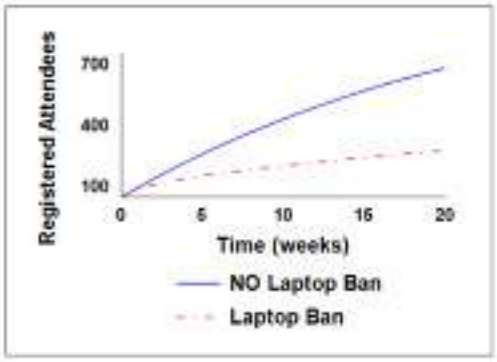

EXERCISE:
Laptop Ban
model piece:
co-flow
CONCEPT: Validity
Checklist
ACTIVITY:
Validate Variable
EXAMPLE:
Schedule Pressure
EXAMPLE: Motivation
as a Variable

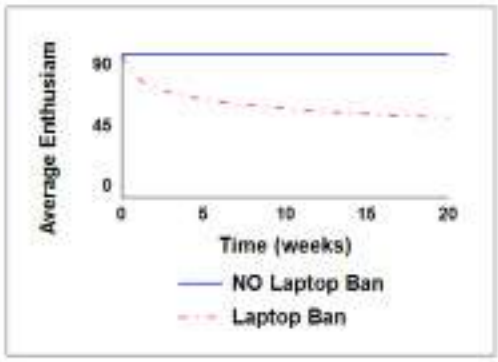
Mid point in registration

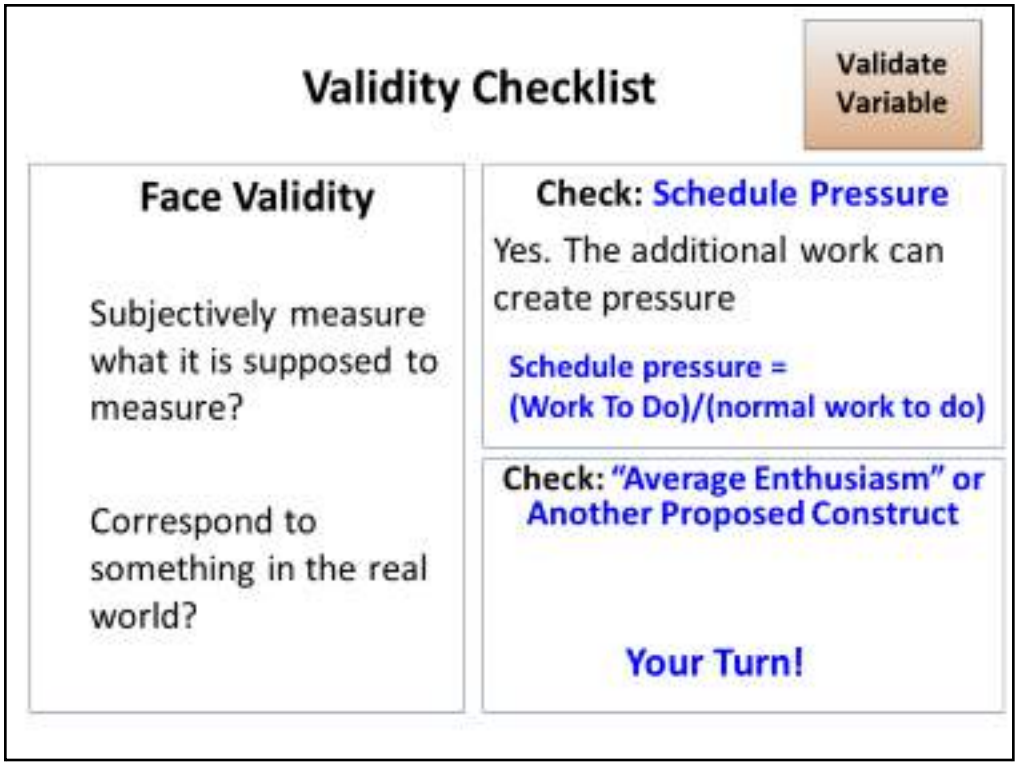


The SDS interventions in green are not activated yet

Results for Case where No SDS Interventions for Laptop Ban







Describe validity check. Give "schedule pressure example." Have open discussion of proposed construct for airline variable.

Combination of Jacobson and Bronson (1987) and Greenstein (2013).

Depression – twenty items related to self and construct [structural equation modeling]. Not empirical factor analysis where you identify factors. Another factor analysis you pick the factors related to a separate domain of the construct.

Validity Checklist

Validate Variable

Content Validity

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

Other dimensions?

Check: Schedule Pressure

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

Check: "Average Enthusiasm" or Another Proposed Construct

Your Turn!

Validity Checklist

Validate Variable

Construct Validity

Correlate appropriately with other theoretical constructs (related and unrelated)?

Check: Schedule Pressure

Yes.

Correlates with burnout and morale, and not sunspots

Check: "Average Enthusiasm" or Another Proposed Construct

Your Turn!

Validity Checklist

Validate Variable

Predictive Validity

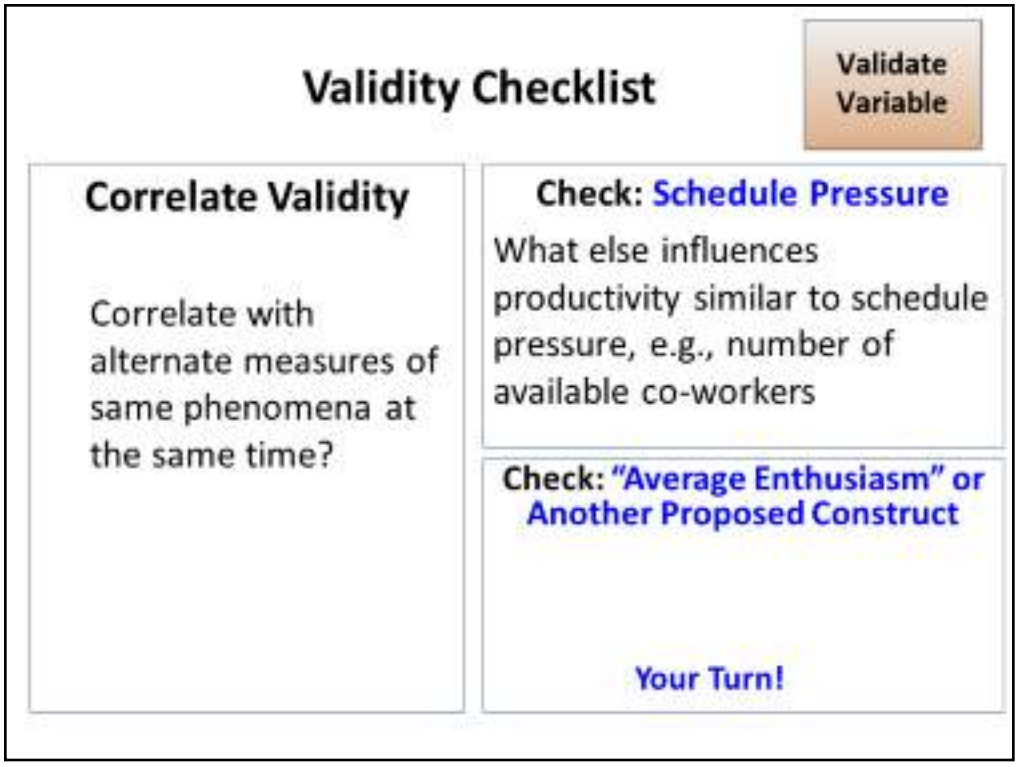
Does it predict future behaviors or conditions?

Check: Schedule Pressure

Does it predict turnover?

Check: "Average Enthusiasm" or Another Proposed Construct

Your Turn!


Validity Checklist
Validate Variable
Correlate Validity
Correlate with alternate measures of same phenomena at the same time?
Check: Schedule Pressure
What else influences productivity similar to schedule pressure, e.g., number of available co-workers
Check: "Average Enthusiasm" or Another Proposed Construct
Your Turn!

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Key Lesson

Assessing at the validity of your variable helps you critique the validity of your model

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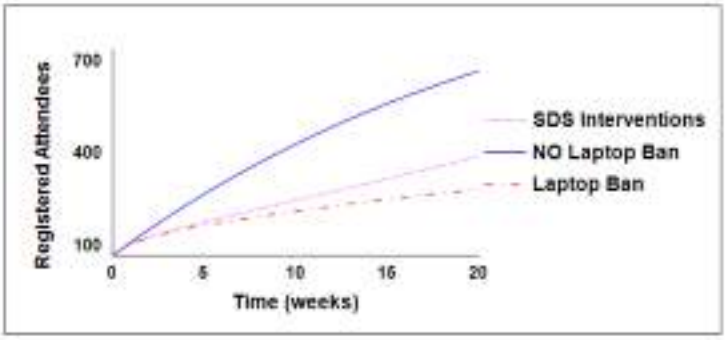
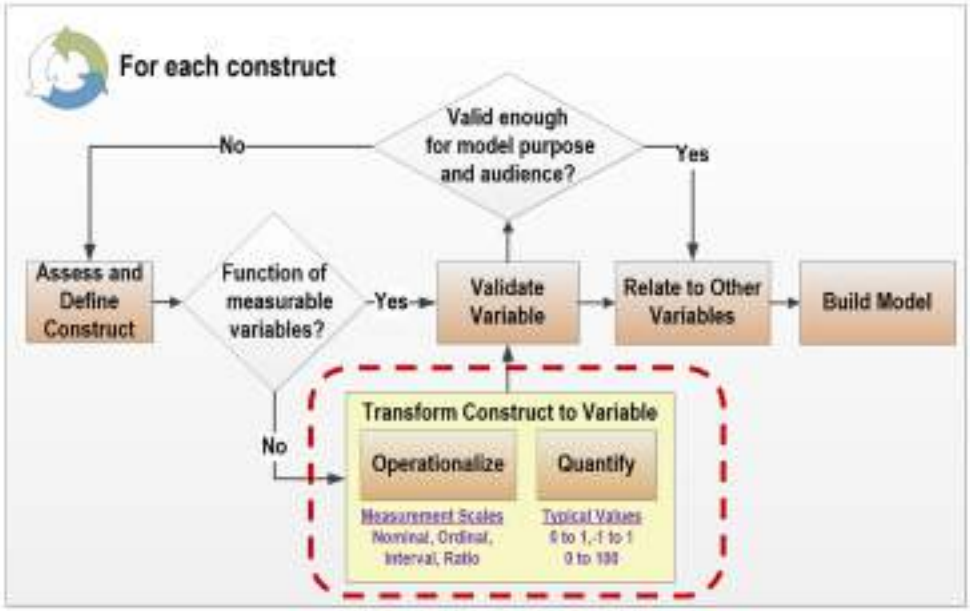
Demo

Airline Laptop Ban Co-flow Model with Intervention



Can have group play with it.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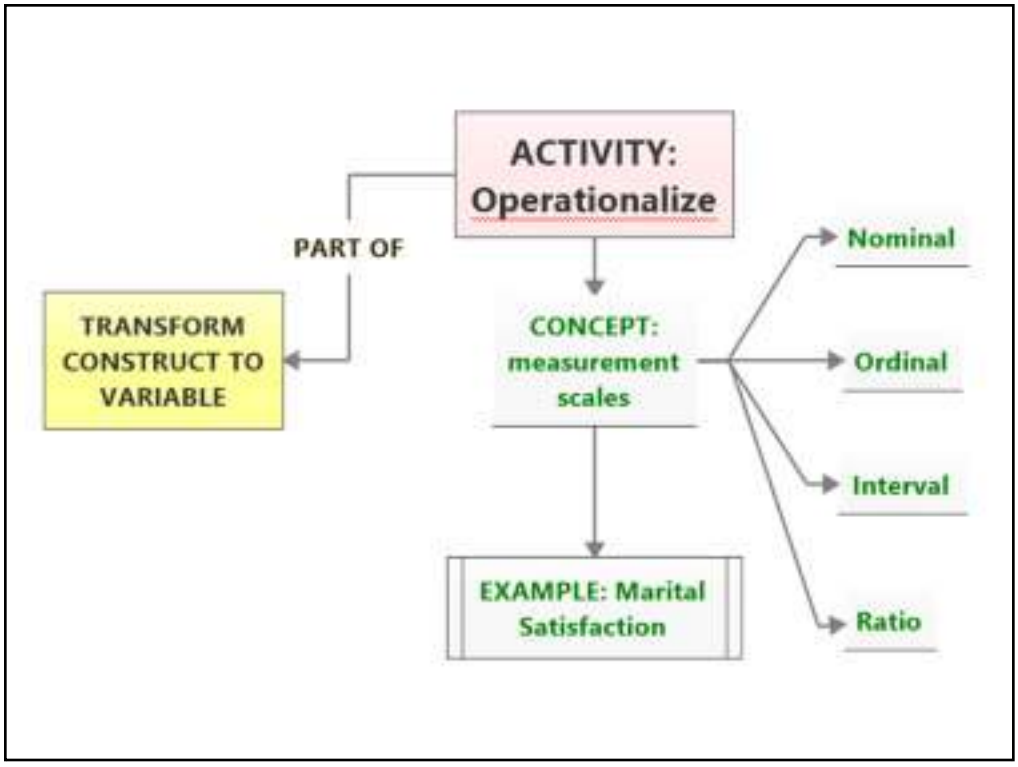

ACTIVITY:
Operationalize
PART OF
TRANSFORM CONSTRUCT TO VARIABLE
CONCEPT: measurement scales
Nominal
Ordinal
Interval
Ratio
EXAMPLE: Marital Satisfaction

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

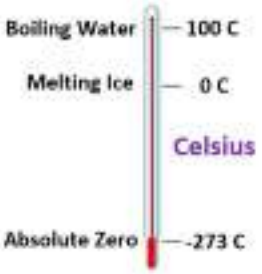
- Nominal scale features
- Indicates direction, ordering of categories

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		

Typically stock and flows typically show variables that are on a ratio scale, other scales can be used and applied in SD models. For example, Nominal can be a SWITCH or a PULSE in a model. We should talk about this, and maybe given a example.

Marital Satisfaction - Ordinal

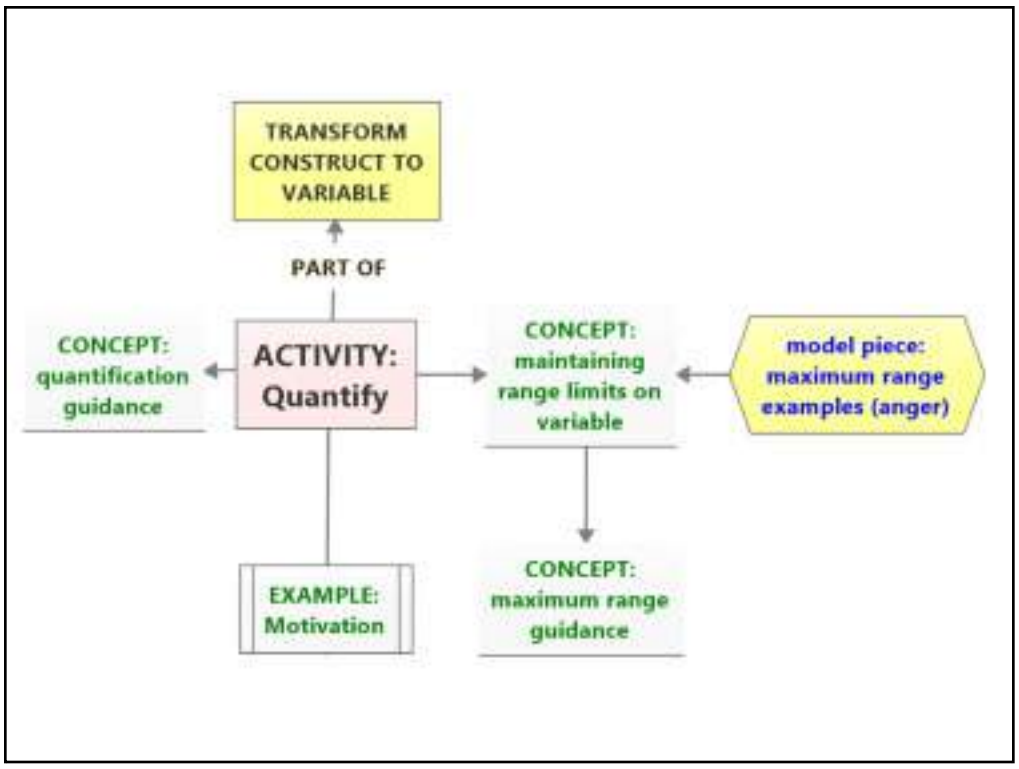
Scale	Question	Response Categories or Assessment
Nominal		
Ordinal	How satisfied are you with your marriage?	'Hot' 'Warm' 'Luke warm' 'Cold'
Interval		
Ratio		

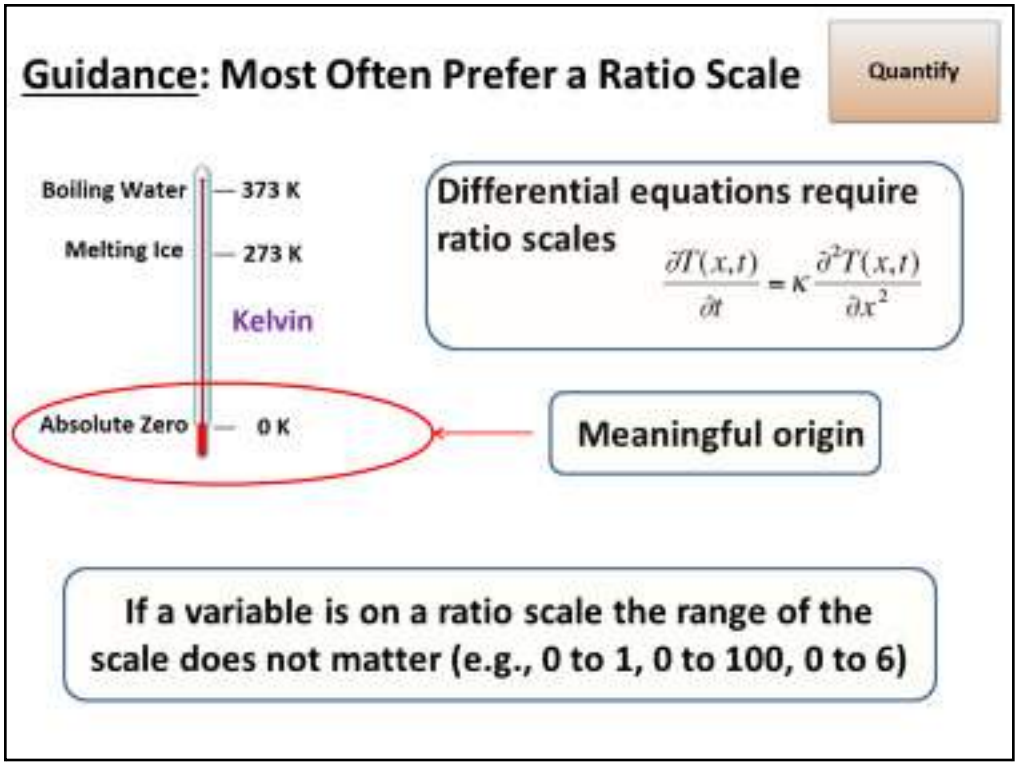
Marital Satisfaction - Interval

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		

Marital Satisfaction - Ratio

Scale	Question	Response Categories or Assessment
Nominal		
Ordinal		
Interval		
Ratio	What is the quality of couple interactions?	Ratio of positive to negative interactions observed over a specified time period (Gottman Ratio)


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

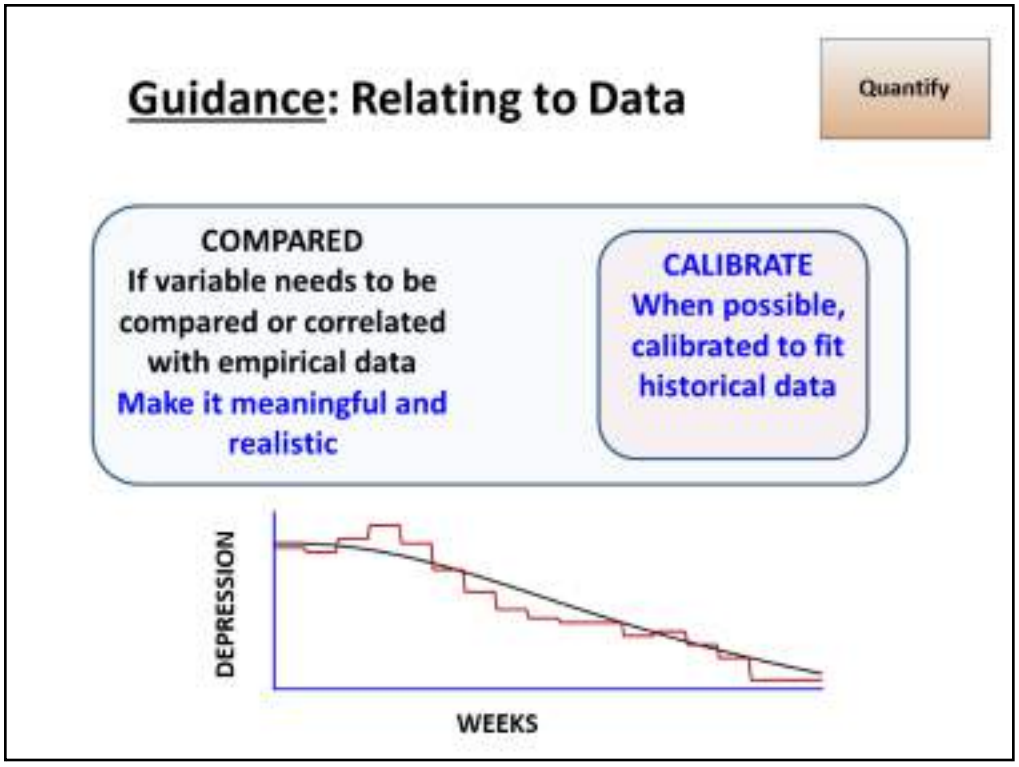


Most often we want variables on a ratio scale

We want a meaningful origin

Differential equations require ratio scales

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



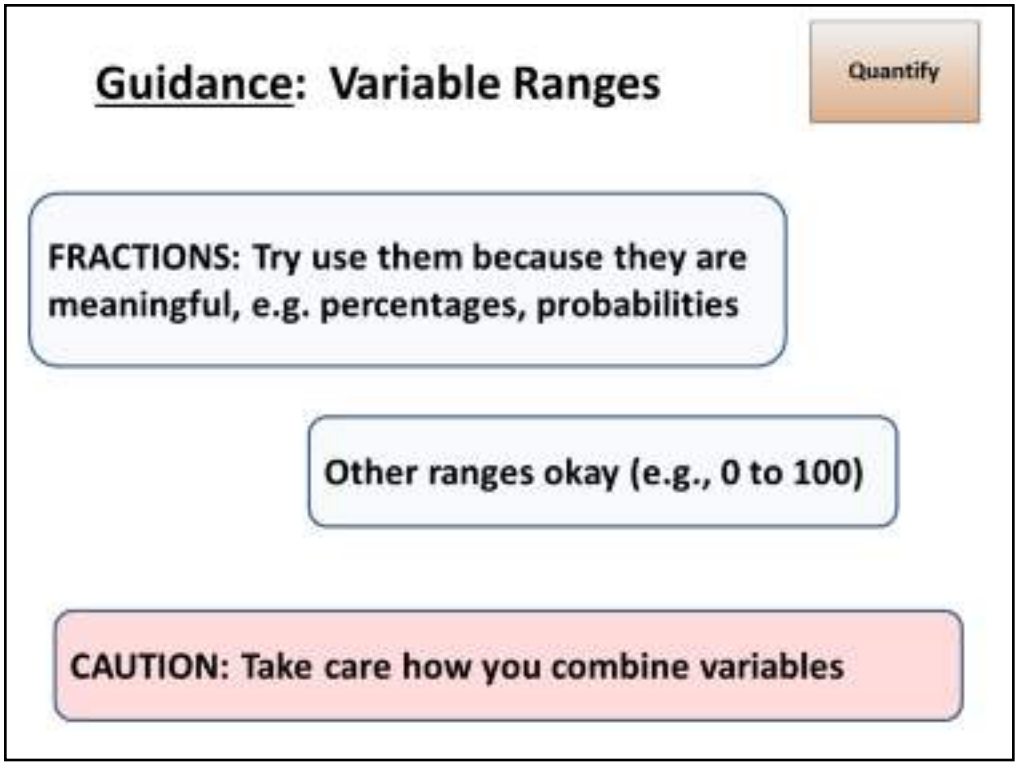
Thinking of an appropriate scale (depression 0 to 100). Need a structure that manages range.

We following people for 6 months, saw depression change (initial value, goal – question)

For example, Beck Depression Inventory

Depression of receiving services in a problem over a period. Choose scale 0 to 100, most come in at an 80. Relate to an instrument that measure depression and scale it.

Look at **Grid-Enabled Measures (GEM) Database.**

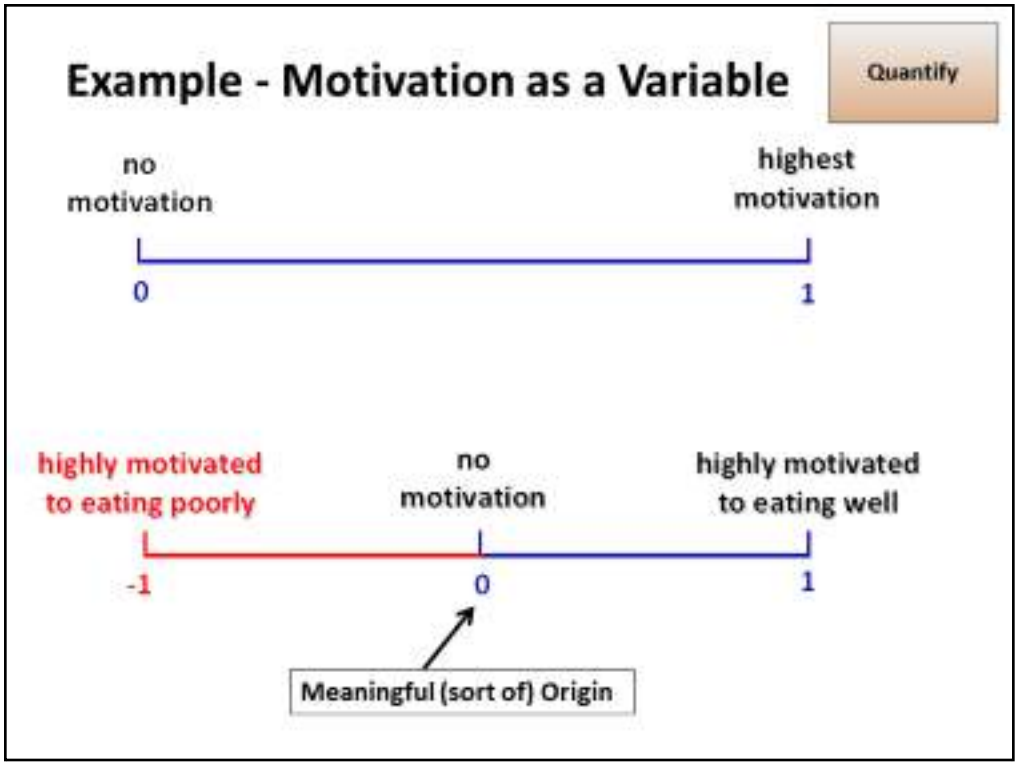


Later we will discuss how we combine variables.

Prefer ratios for graphical functions.

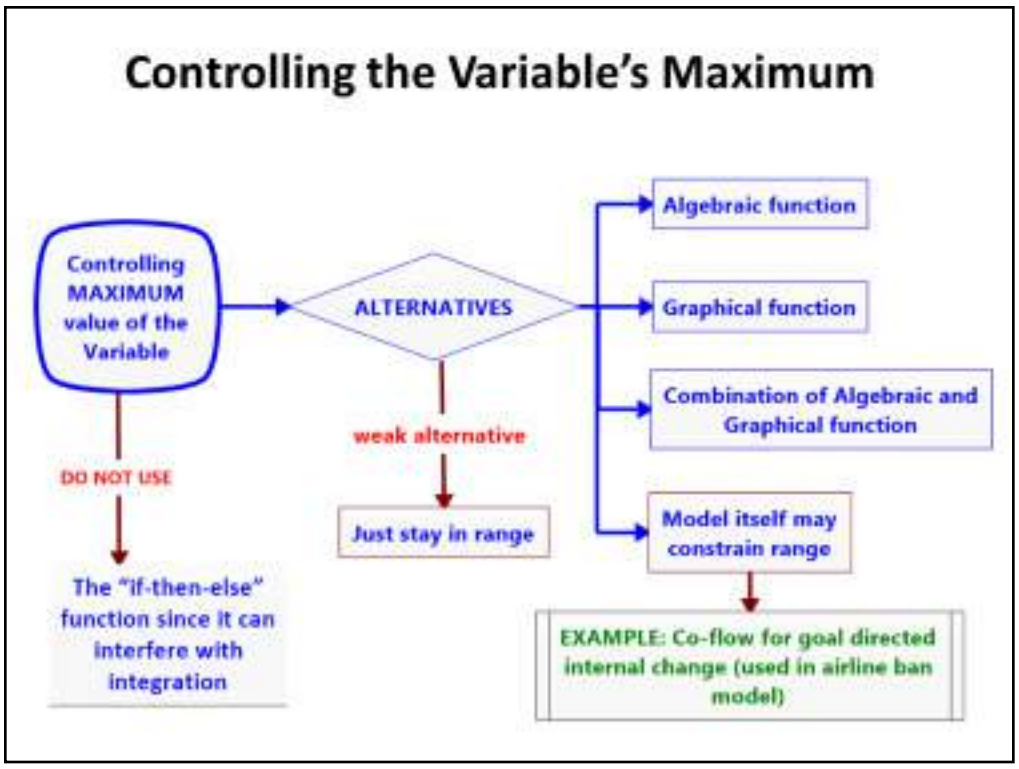
Taking care means making sure (via graphical functions or cognitive algebra) that all variables in the model remain in range.

MENTION: We will cover this topic later



If something is zero it cuts things off. Could have multiple multipliers. Be careful where you end up. Be careful of potential ranges.

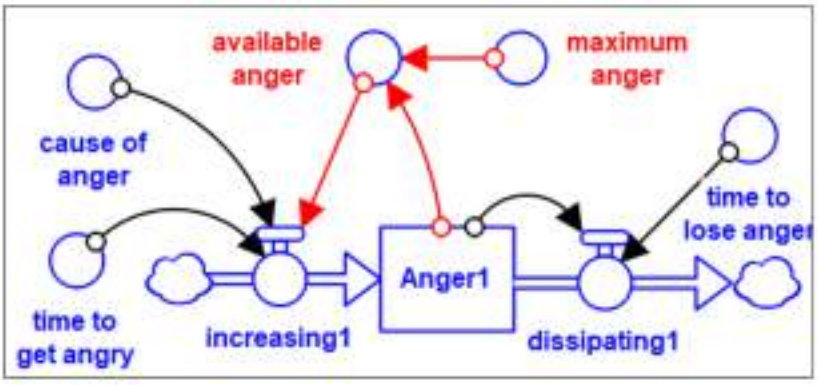
Consider: motivation scale is from M = 1 to M = 10, with M < 4 considered unmotivated



What have you used in your models, how have you done it?

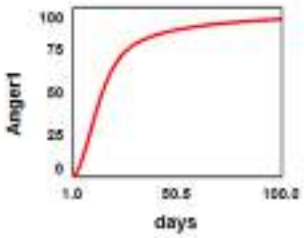
Need to stay in range anyway, no alternative is perfect (Story – Jim looks as wood as malleable and flexible)

Algebraic Function Limits Upper Range



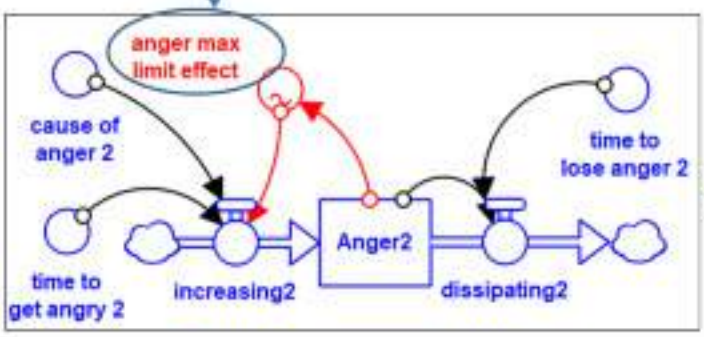
increasing1 = (cause of anger *available anger)/(time to get angry)

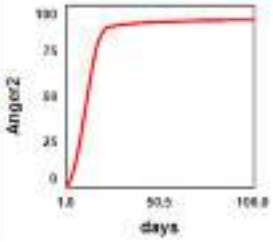
available anger = (maximum anger – Anger1)/(maximum anger)

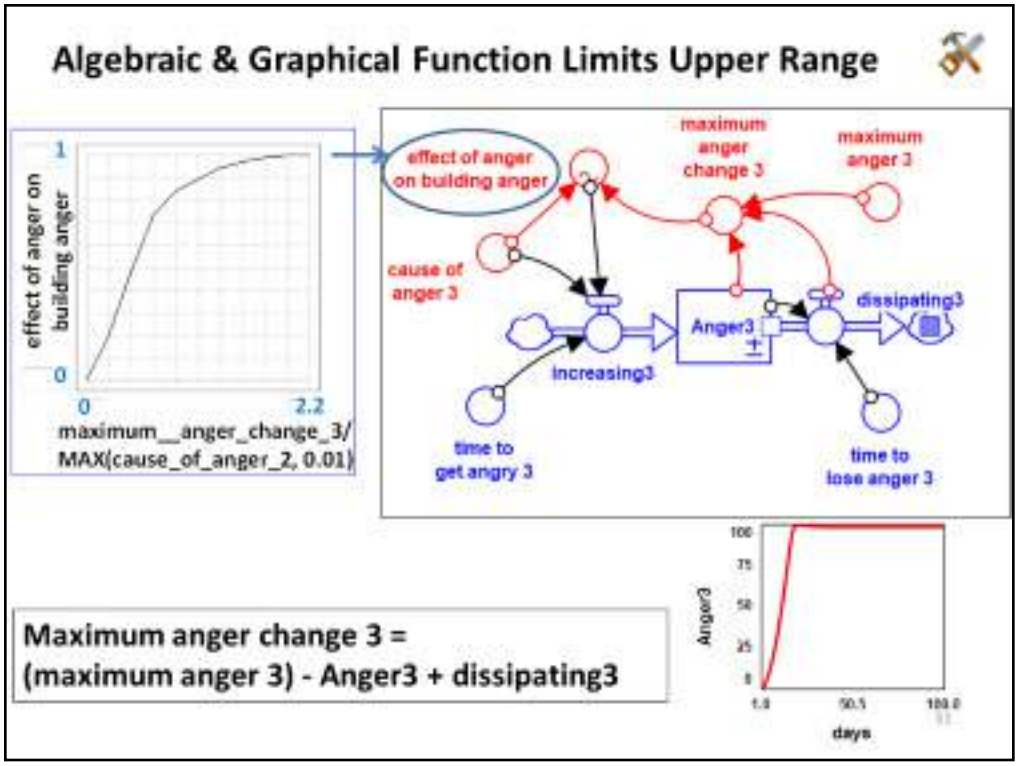


Graphical Function Limits Upper Range

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







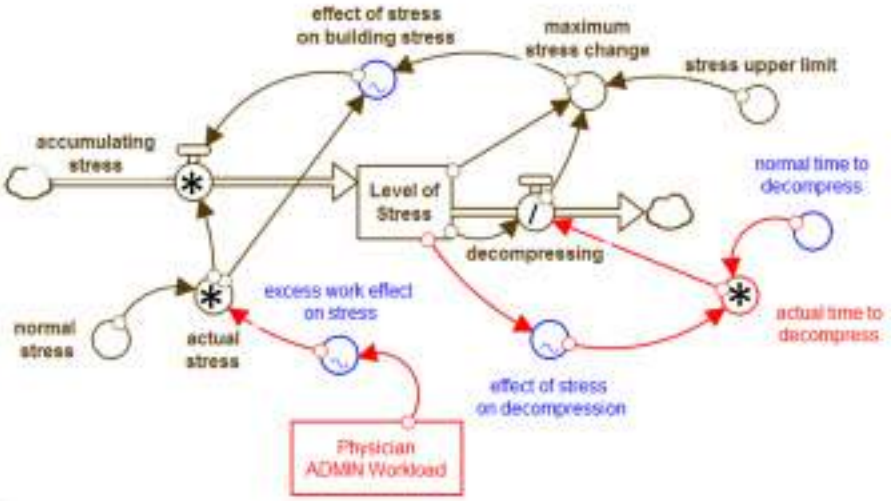
Meta-states. Effect of anger on building anger is a meta-state

See http://pascalgambardella.com/blog/wp-content/uploads/metastates-and-frames-23-May-2017-v3.jpeg

Suppose you see a potential danger and feel fear. The state of fear is called a primary state since it is triggered from outside of you. Being human, you will probably reflect on that fear. Many of us have been ashamed of being afraid. That is a meta-state, a state about another state, and is triggered from within yourself. It sets a new frame of meaning for that original state. Now, your relationship with the state of fear is shame: shameful fear. How would you experience fear differently if instead you were curious about your fear? All states that begin with self (e.g., self-confidence, self-esteem, and self-efficacy) are meta-states. Sometimes this self-reflection places us in a state of mind (e.g., feeling anxiety) that is not useful. Other times, our self-reflection and meta-states place us into highly desirable states, such as joyful learning or intelligent, fearless risk-taking. Self-reflection can give us the ability to gain new perspectives, understandings, insights, and choices. Using the Meta-States Model lets you look at your meta-states, and the actions, beliefs, values and decisions they drive. This enables you to use them to actively manage your mental and emotional states to enhance your well-being and performance

This is part of a Resource Page: https://pascalgambardella.com/resources/resource-maps/

Another Example: Stress



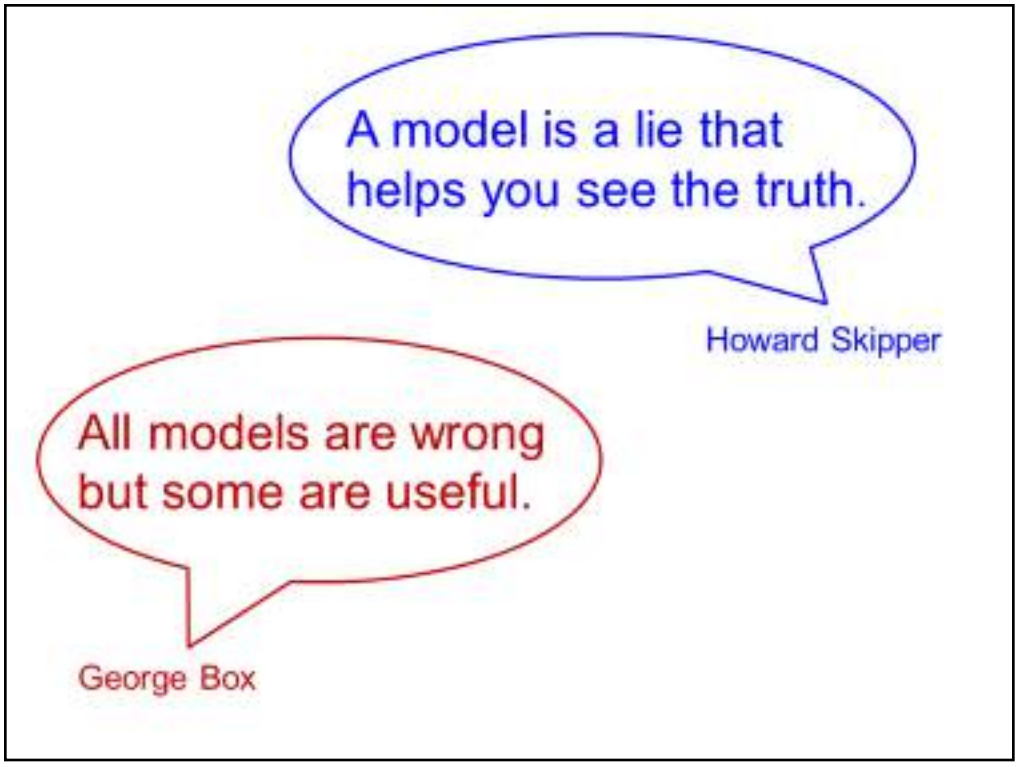
maximum stress change = (stress_upper_limit - Level_of_Stress) + decompressing

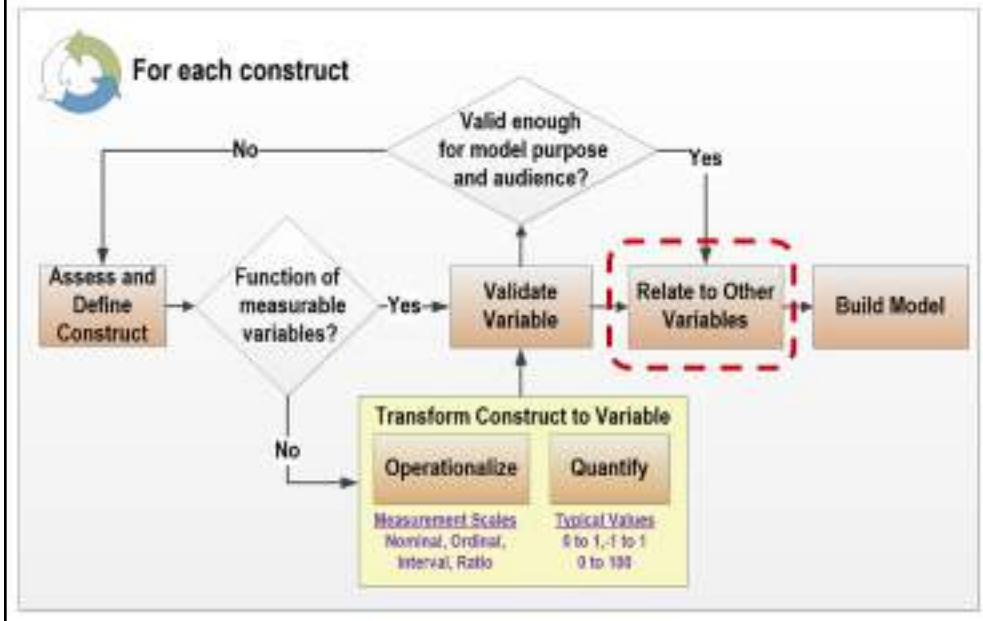
1 – Preliminaries

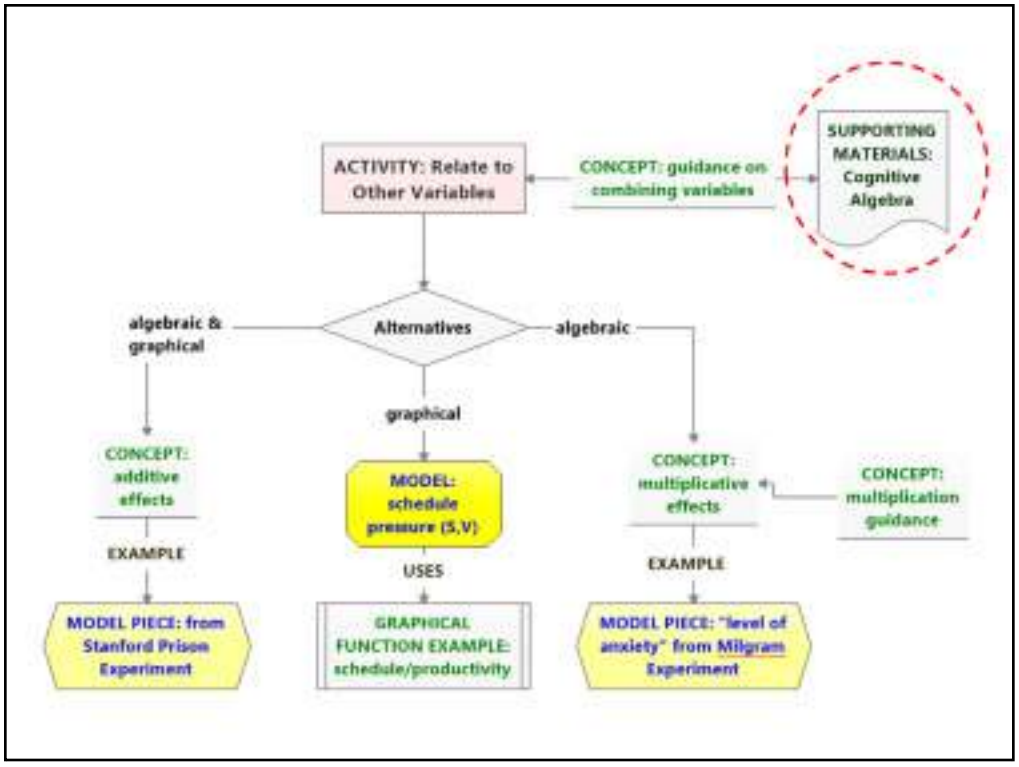
2 – Modeling Approach

3 – Defining and Transforming "Soft Constructs" to Variables

4 – Modeling Building Mechanics


A model is a lie that helps you see the truth.
Howard Skipper
All models are wrong but some are useful.
George Box


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



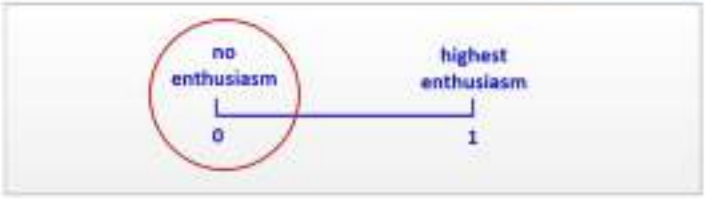
Mention that Cognitive Algebraic is in the supporting materials. It is an advanced topic and won't be covered here.

It is a way of combining variable to maintain a given range.

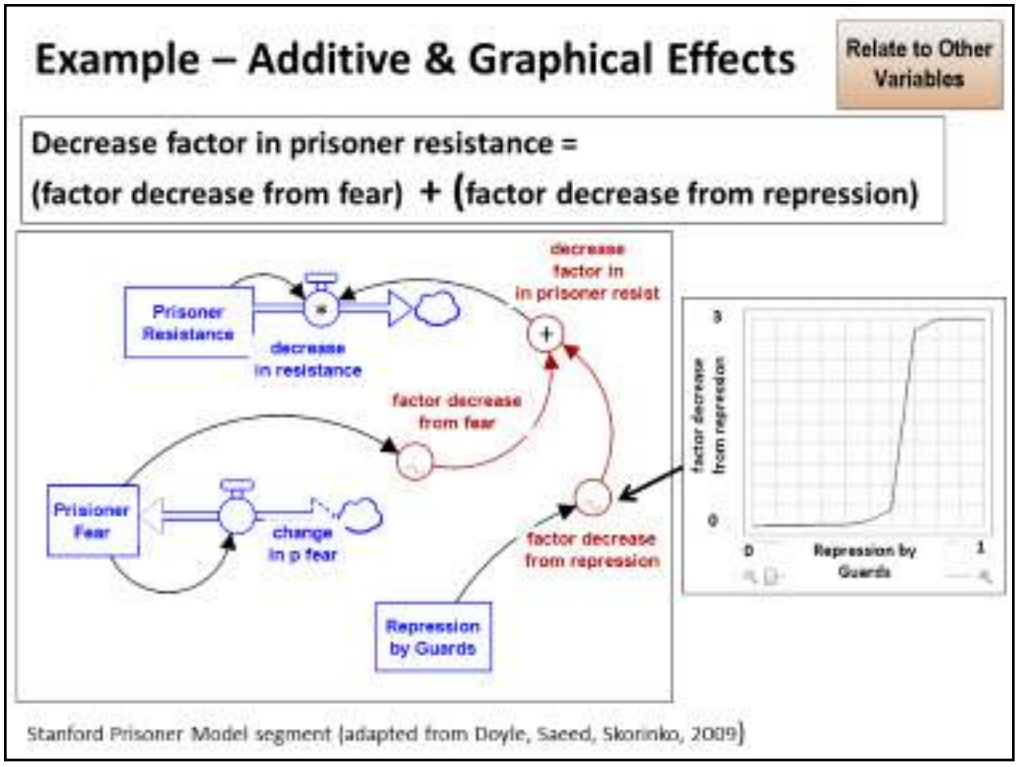
Guidance on Combining Variables

Relate to Other Variables

Have a meaningful origin



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



We change the model. Change in Resistance -- "decrease to change"

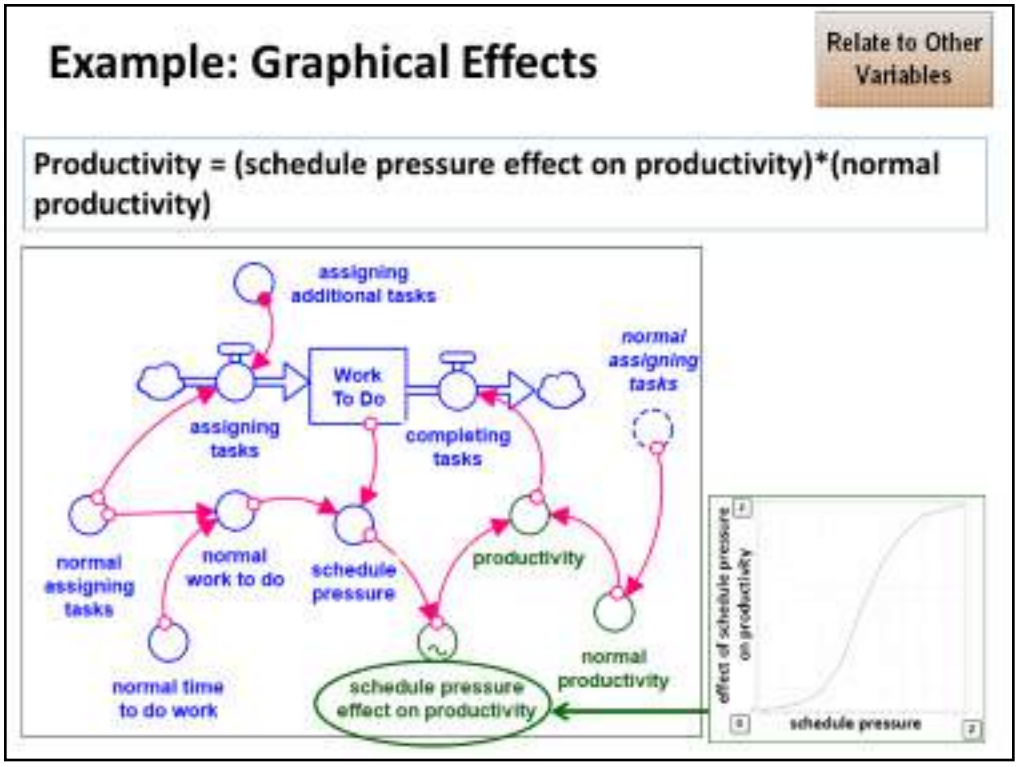
You could add two things and divide by the total like a probability.
Make sure "ranges" work

Describe diagram. All psychological variables are between 0 and 1.

Ask what could go wrong? Need to protect Prisoner Resistance from going below zero. Be careful of ranges. They have a defined maximum effect. Need to see rest of model to judge other effects.

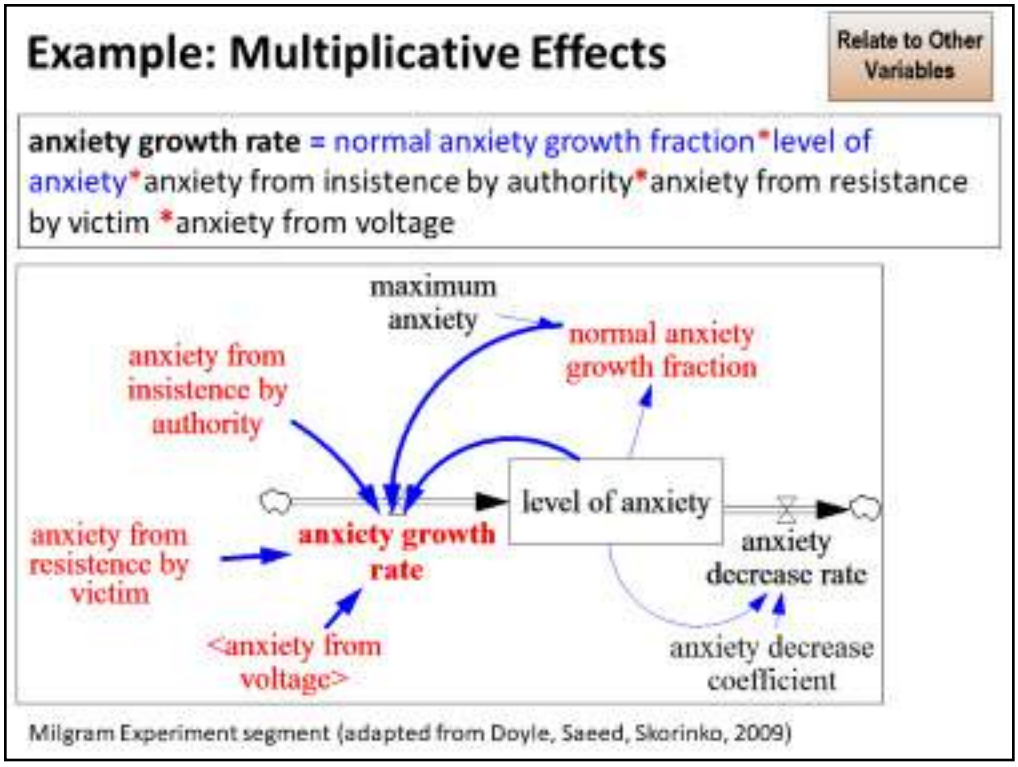
Would a multiplicative effect work, probably not?

Doyle, J., K. Saeed and J. Skorinko (2009). Personal versus Situational Dynamics: Implications of Barry Richmond's Models of Classic Experiments in Social Psychology Proceedings of the 27th International Conference of the System Dynamics Society. Albuquerque, New Mexico, System Dynamics Society.



We have not limited schedule pressure directly. However, as it increases productively will taper off, and likely decrease in the real world. Also there will be more errors (not modeled). The graphical function controls this effect. On this model schedule pressure above 2 is not supported by the graphical function.

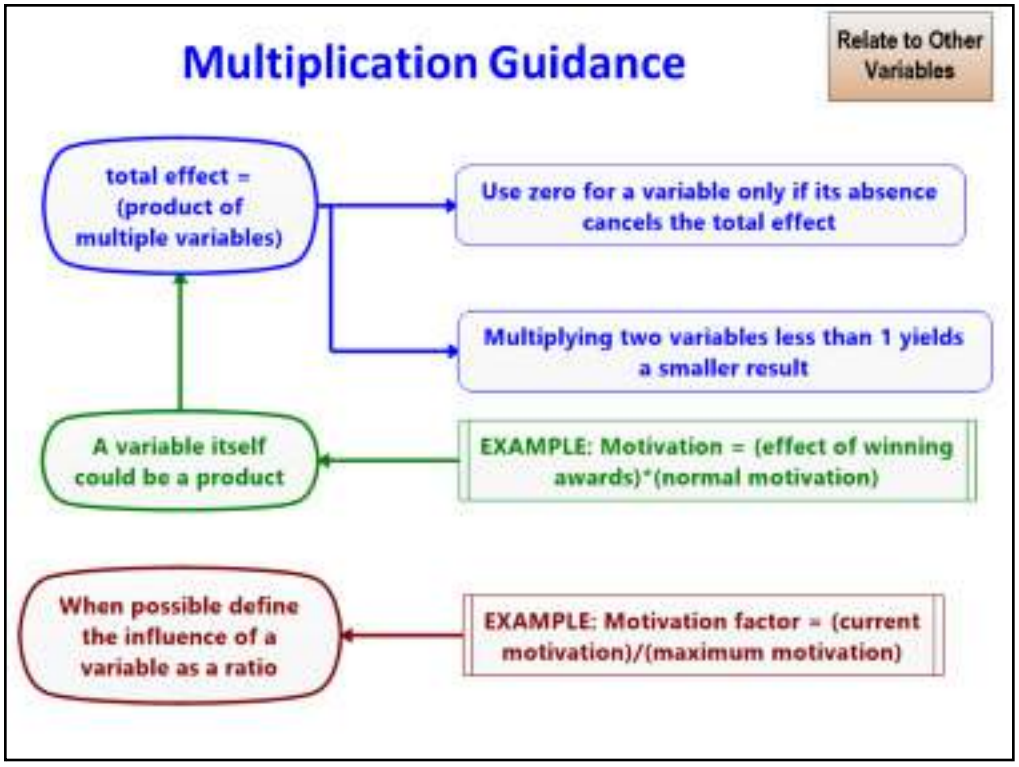
Notice when schedule pressure = 1, productivity = 1

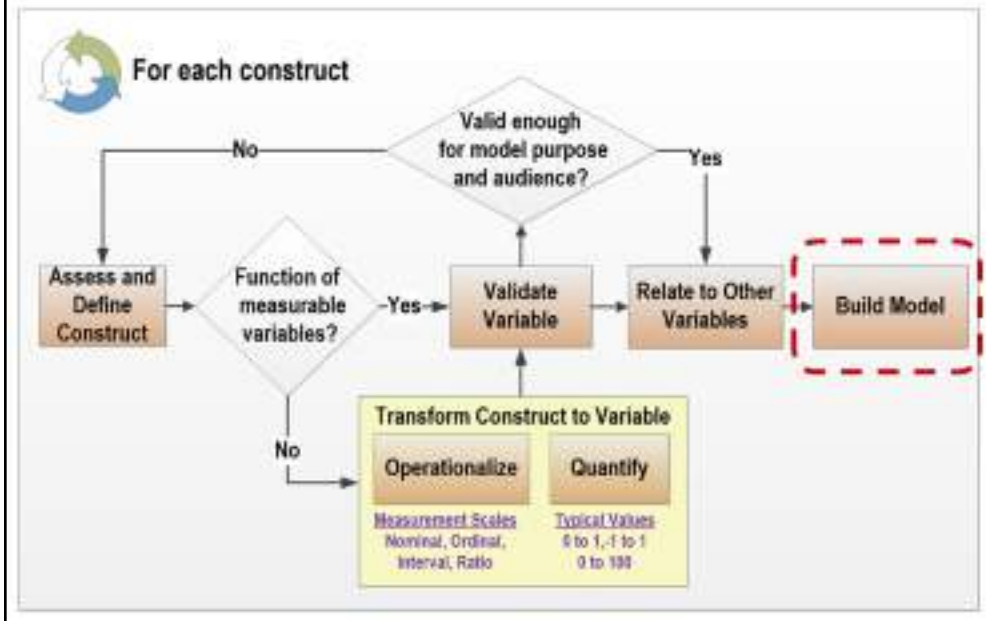


More factors more anxiety

Reasoning behind limiting factors. Can we combine these as a macro variable. Use sensitivity testing – are all needed? Could they be an index. Idea – look at index and work backward (burnout). What region is considered burnout? Threshold above or below constitutes burnout. People may have published info about this threshold. Distress: (0 to 10), 4 and above clinical, take action.

Implications for using zero on ratio scale.


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)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Validate Variable
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Build Model
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Transform Construct to Variable
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Quantify
Measurement Scales
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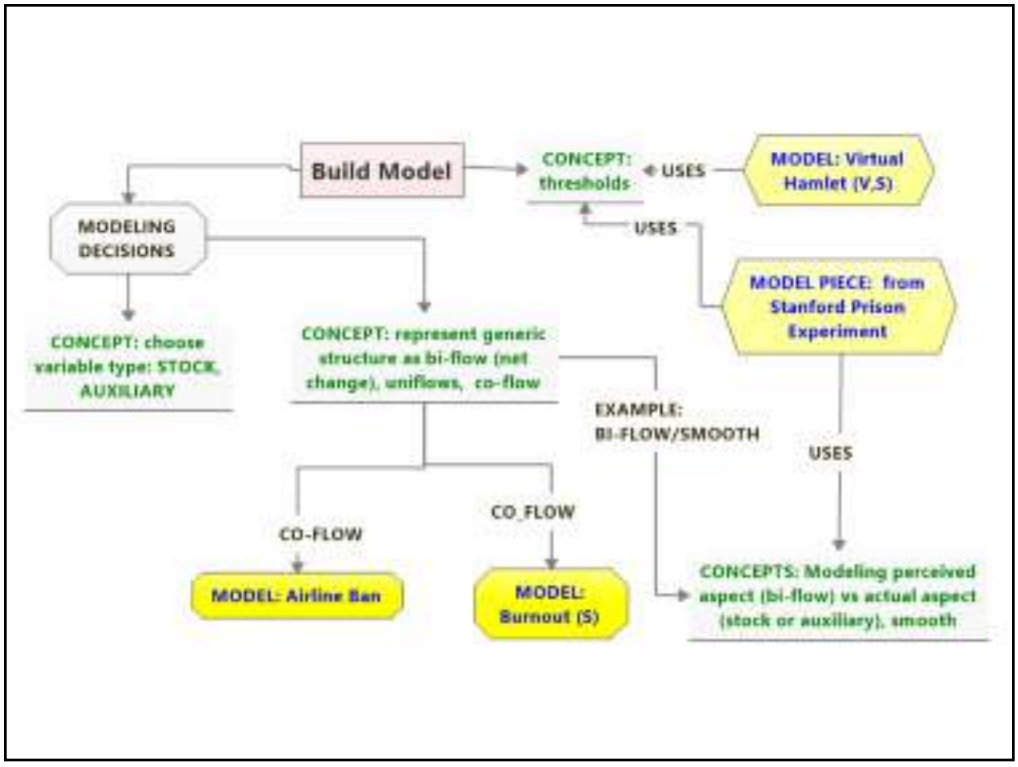
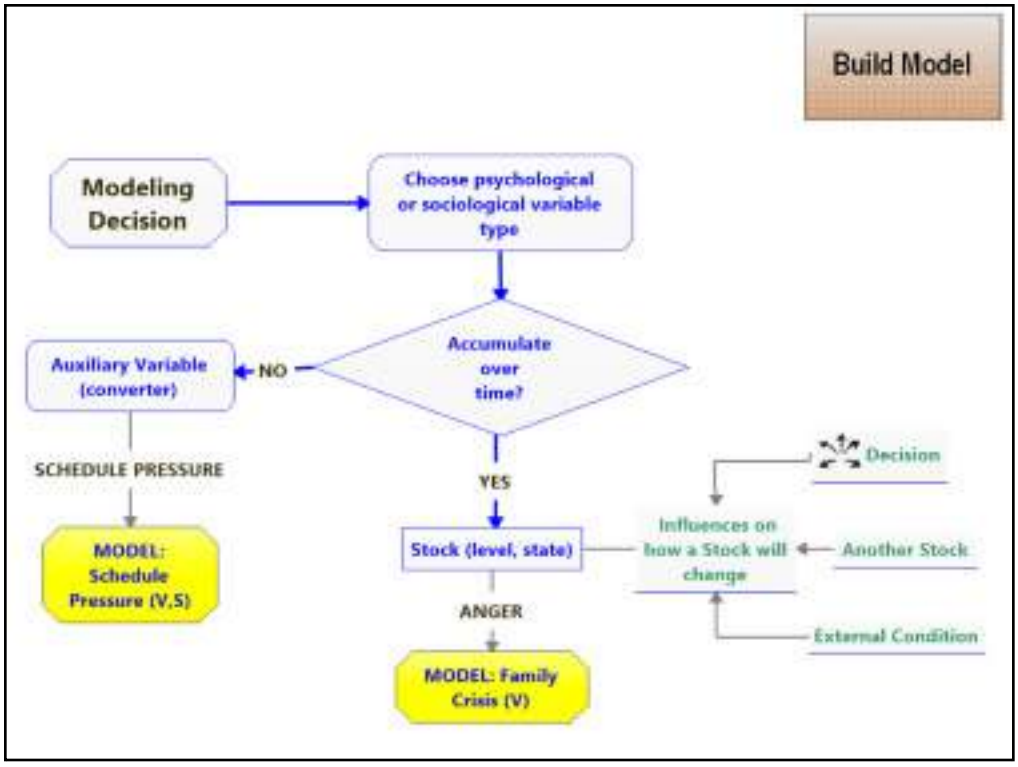
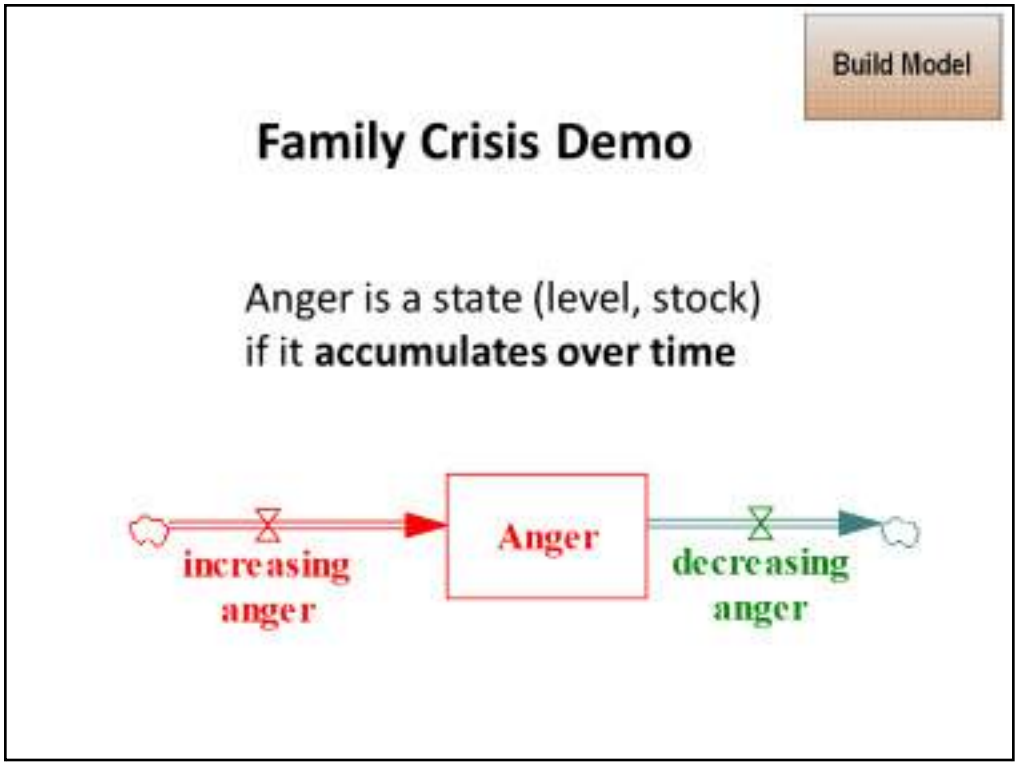
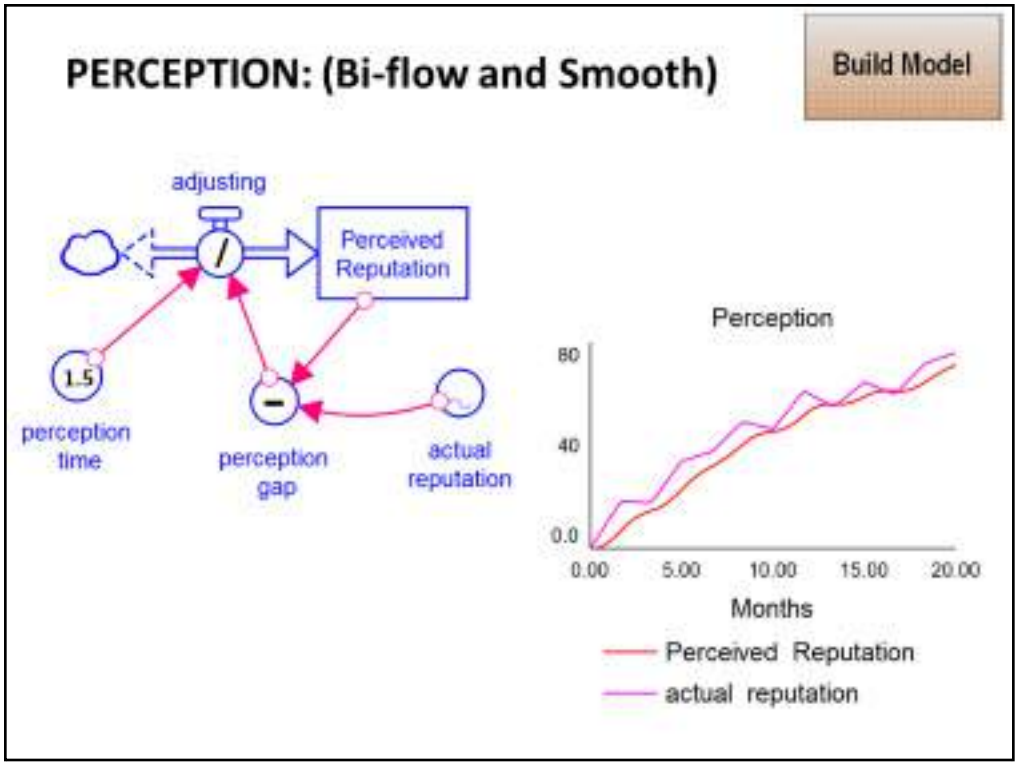

Build Model
CONCEPT: thresholds
USES
MODEL: Virtual Hamlet (V,S)
MODELING DECISIONS
USES
MODEL PIECE: from Stanford Prison Experiment
CONCEPT: choose variable type: STOCK, AUXILIARY
CONCEPT: represent generic structure as bi-flow (net change), uniflows, co-flow
EXAMPLE: BI-FLOW/SMOOTH
USES
CO-FLOW
CO_FLOW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

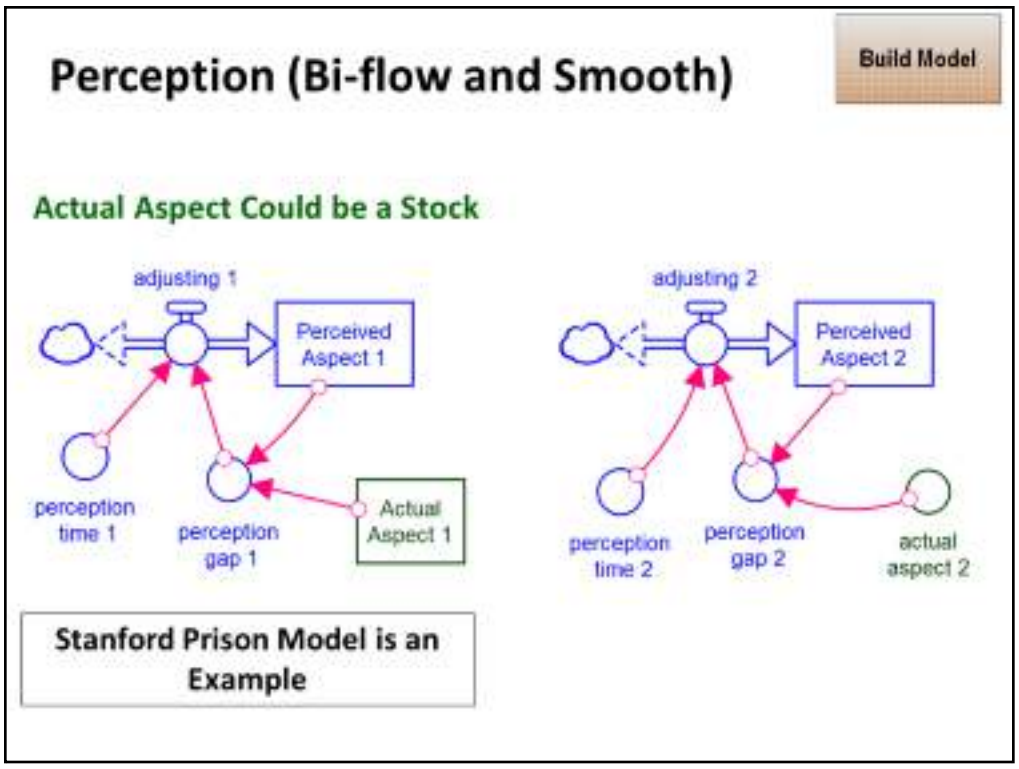

Build Model
Modeling Decision
Choose psychological or sociological variable type
Accumulate over time?
NO
Auxiliary Variable (converter)
SCHEDULE PRESSURE
MODEL: Schedule Pressure (V,S)
YES
Stock (level, state)
ANGER
MODEL: Family Crisis (V)
Influences on how a Stock will change
Decision
Another Stock
External Condition



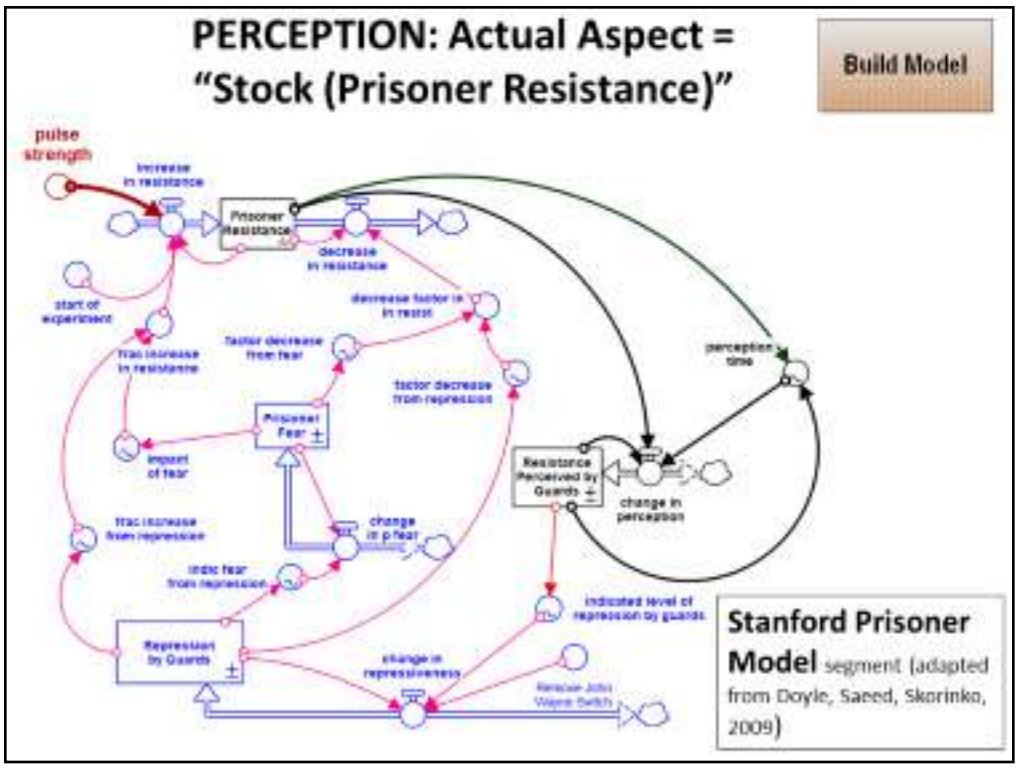
Auxiliaries are just for convenience and visibility. They can be placed in rates. [review]



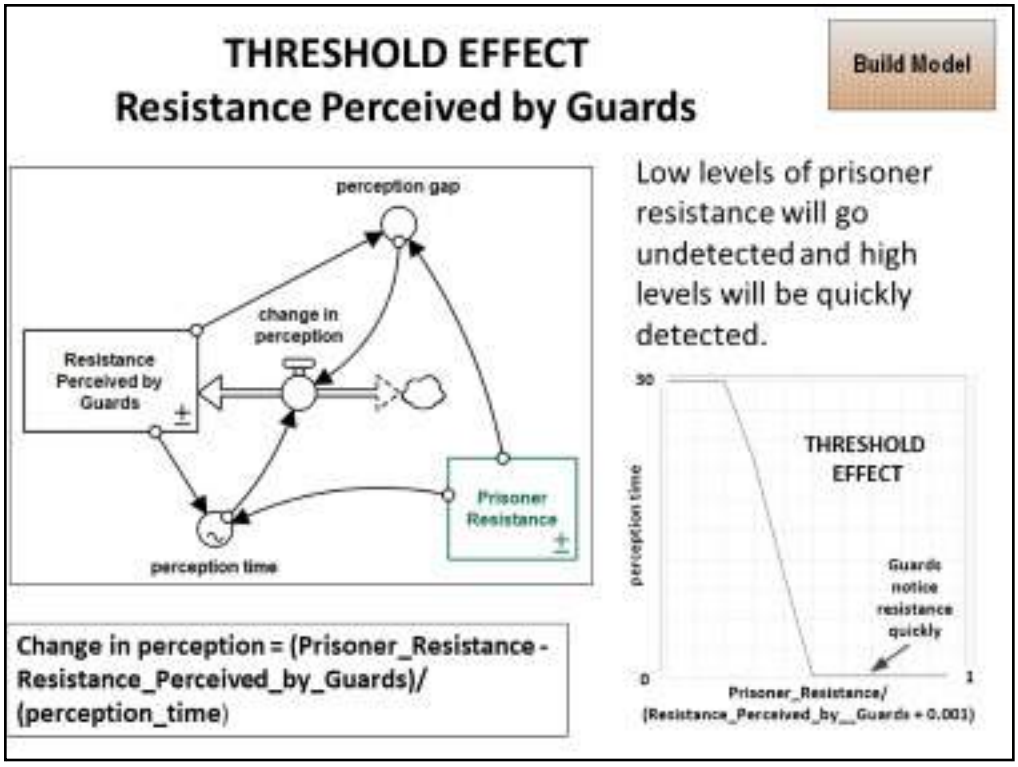
Perception time or fractional rate



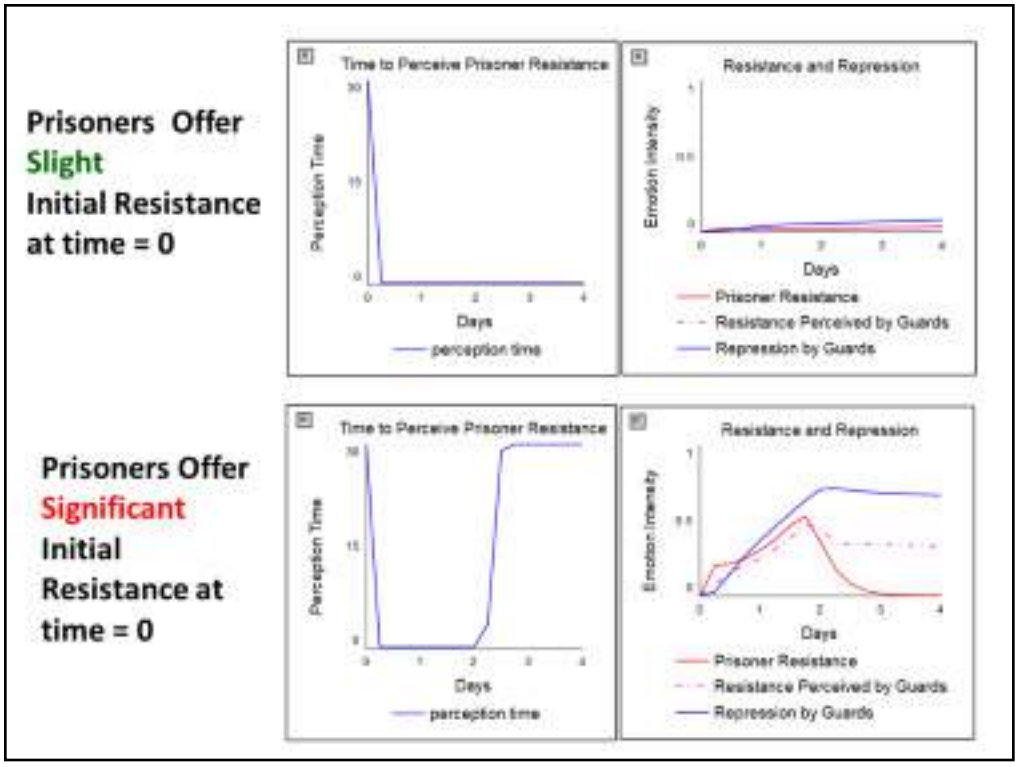
This is about an abstract aspect of some variable. Not quality (how well something is done) itself which is an auxiliary variable. Average quality is a stock.



Guards are ordinary people.



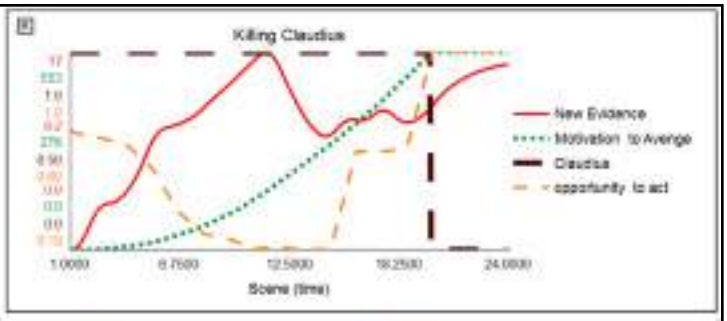
Lowest value is 0.25



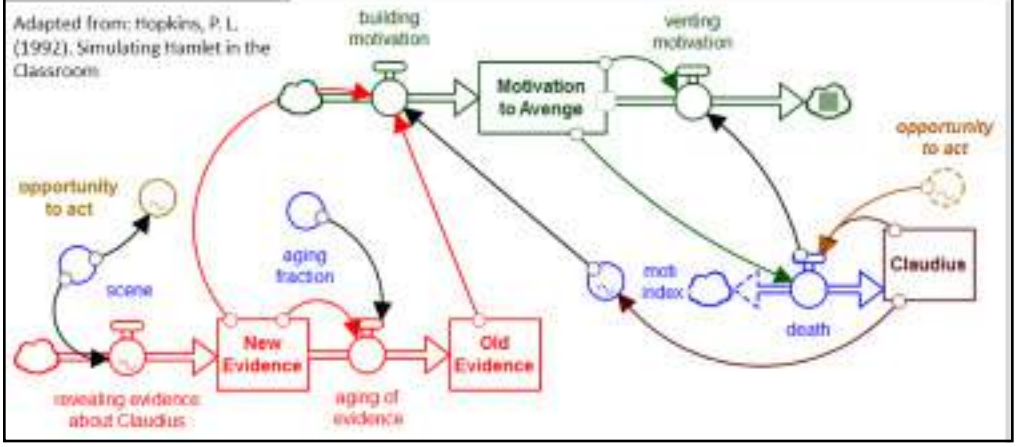
In model, pulse = 0.02 low resistance, pulse = 0.2 high resistance

If the pulse is large enough, the guards push the prisoner's resistance to zero: Resistance is Futile.

Hamlet – Opportunity, Motivation, Revenge

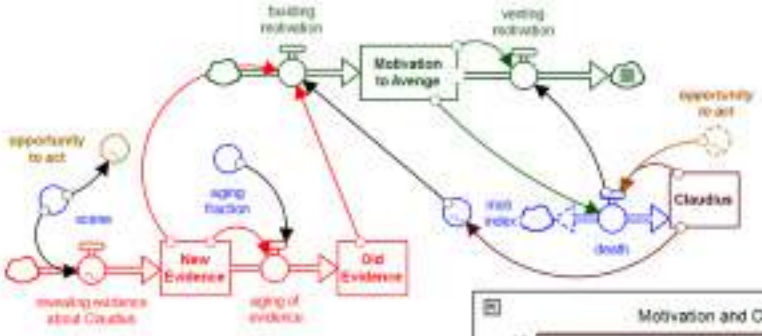


Adapted from: Hopkins, P. L. (1992). Simulating Hamlet in the Classroom

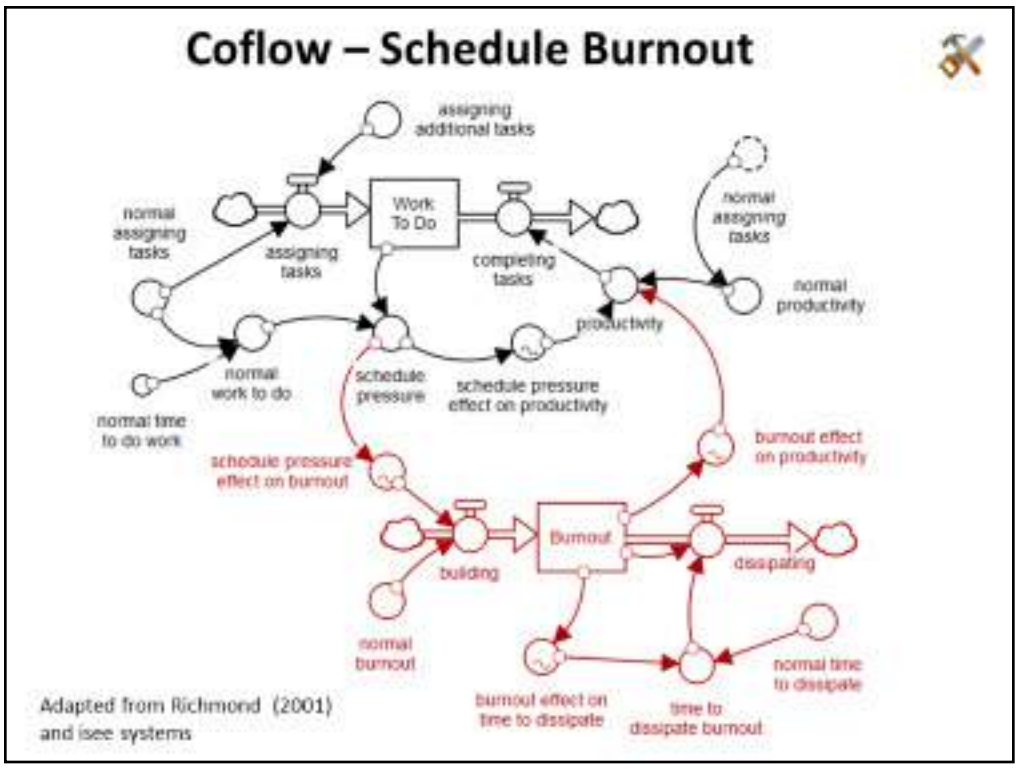


THRESHOLD EFFECT: Killing Claudius

Build Model



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



Note:
Initial Condition for burnout stock: normal_burnout*normal_time_to_dissipate

Keeps burnout in equilibrium until additional tasks assigned

If normal_time_to_dissipate not present, burnout will gradually increase starting at time zero.

When no additional tasks assigned, schedule pressure = 1 and the equilibrium condition for burnout is
schedule_pressure_effect_on_burnout*normal_burnout = normal burnout = Burnout/time_to_dissipate_burnout

initial condition of burnout = normal burnout * time_to_dissipate_burnout

RESOURCES

Supporting Material

- Annotated Bibliography of Psychological and Sociological Modeling
- Advanced Topic - Cognitive Algebra
- Example Models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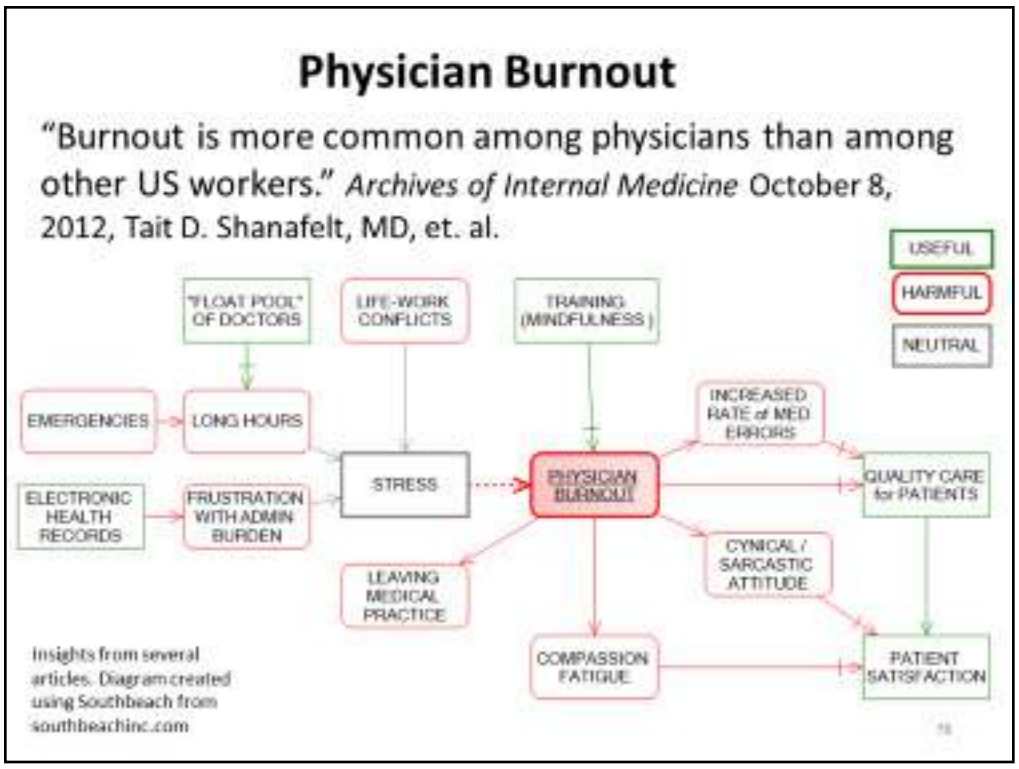
David

APPENDIX
Physician Burnout

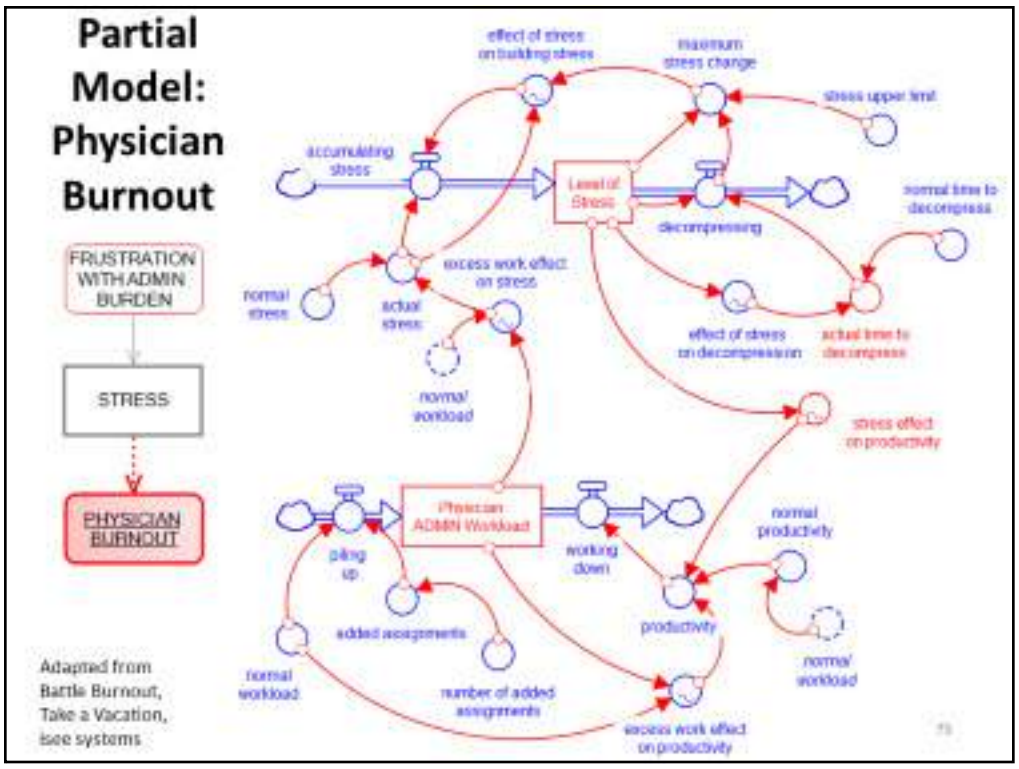
Working Model



With Burnout you do not bounce back or recover with rest or time off (like you can with normal stress).

"Burnout and Satisfaction With Work-Life Balance
Among US Physicians Relative to the General US Population"
Archives of Internal Medicine October 8, 2012. Tait D. Shanafelt, MD, et al
http://archinte.jamanetwork.com/article.aspx?articleid=1351351

Talk about a legend.



Compare this model with the model with schedule pressure. Battle Burnout, Take a Vacation

Physician Burnout

Sketch how you would add the following to the burnout model

- Mindfulness practice
- Long hours due to an emergency

Hints:

- Just add auxiliary variables (e.g., normal number of patients, emergency patients)
- What variable would practicing mindfulness most affect?
- The "added assignments" and "number of added assignments variables" may not be needed