PSY 9555A – SEM: Sep 25 – Steps in SEM

RAM Symbolism

Let's start with SEM symbols, diagrams, and parameters:

- RAM symbolism (McArdle-McDonald reticular action model)
- We only need a small set of symbols:

- square/rectangle: observed/measured variables

- circle/ellipse: latent variable including unobserved residual variances

- triangle with a "1" inside: intercept and specifies a mean structure

- one-way arrow: direct effect of one variable on another (regression coefficient)

- Two-way arrow: covariance/correlation between two variables

- Two-way arrow re-entering the same variable: variance of exogenous variable

Parameters

And now the parameters that go with the arrows in measurement and structural models:

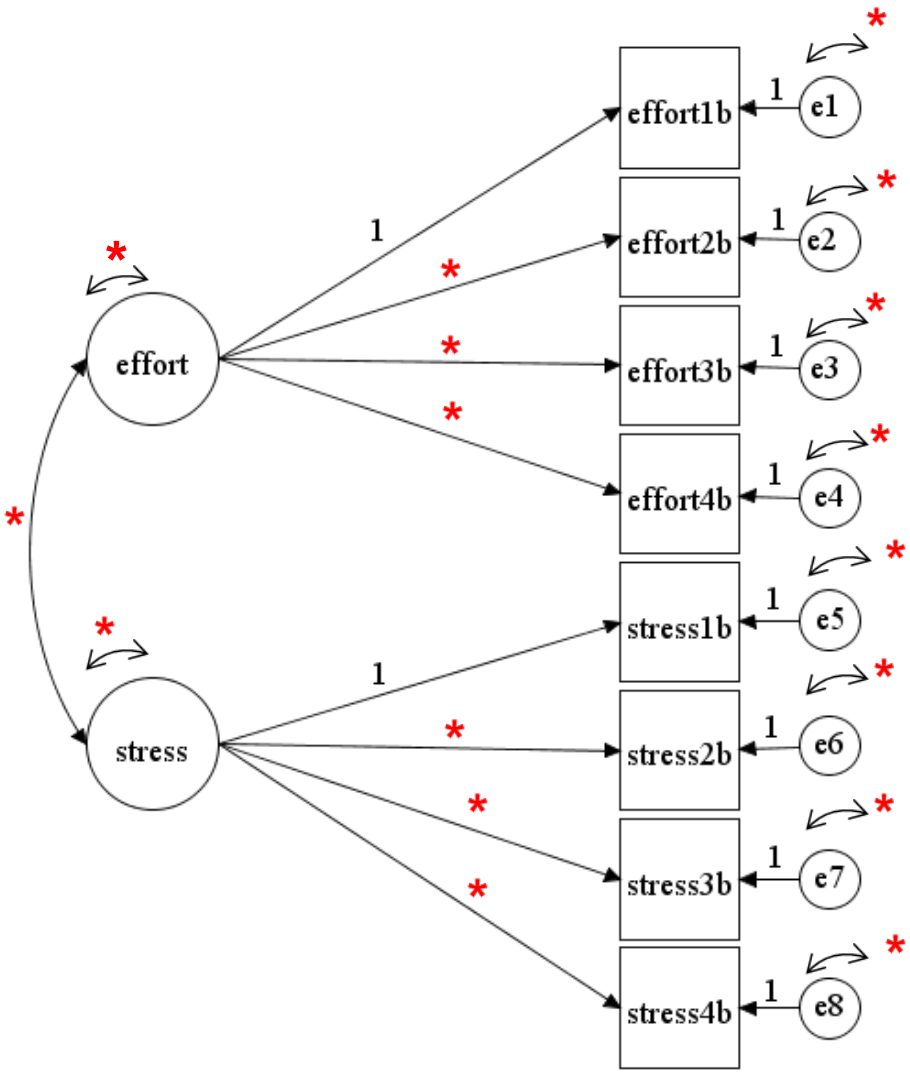
- Measurement model (CFA):
  - pattern coefficients (factor loadings)
  - correlations/covariances between latent variables or unique/residual variances
  - variances of latent variables and unique/residual variances
  - means of latent variables and intercepts of indicator variables
- Structural model (i.e. the structural component of a full SEM model)
  - Regression coefficients
  - Residual variances associated with endogenous variables
  - Correlations between residual variances

Parameter Status

And a parameter status needs to be specified each:

- Free parameter (as in free to be estimated by the SEM program)
- Fixed at a specific value
    - Fixing the scale of a latent variable at 1
    - Applying a reliability estimate to a latent variable with a single indicator
- Constraining parameters (usually to equality)
    - Often in multiple-groups analysis to assess measurement invariance
    - Testing psychometric properties of tau-equivalent or parallel items

Example: CFA



* Parameters that will be estimated (17)

Example: CFA

Variance-covariance matrix of observed variables

Covariances	STRESS1B	STRESS2B	STRESS3B	STRESS4B	EFFORT1B
STRESS1B	2.949				
STRESS2B	2.240	2.860			
STRESS3B	2.304	2.434	3.100		
STRESS4B	2.202	2.191	2.312	2.900	
EFFORT1B	0.463	0.404	0.411	0.446	2.806
EFFORT2B	0.448	0.727	0.514	0.447	1.981
EFFORT3B	0.283	0.486	0.624	0.340	1.910
EFFORT4B	0.406	0.393	0.359	0.648	2.050

Covariances	EFFORT2B	EFFORT3B	EFFORT4B
EFFORT2B	2.631		
EFFORT3B	2.023	2.985	
EFFORT4B	1.795	1.940	3.014

* Parameters that will be estimated (17)

Number of elements in this matrix = v(v+1)/2 = 8x9/2 = 36

Degrees of freedom = number of elements – number of estimated parameters

36 – 17 = 19 df

Example: CFA

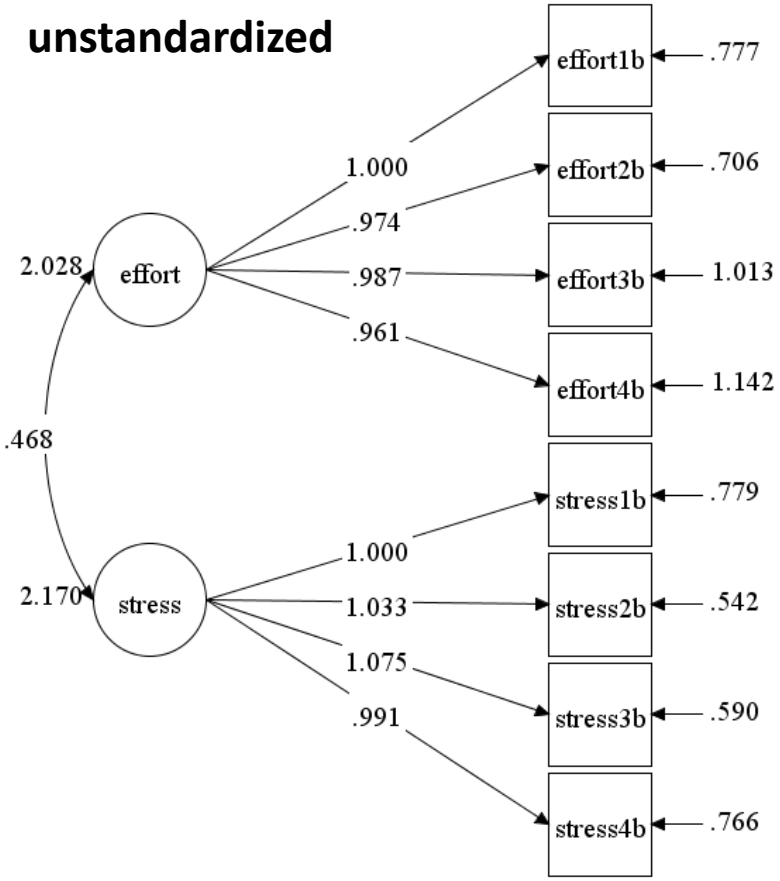
Note:

- Mplus includes the mean structure when calculating parameters and degrees of freedom. We will learn this later.
- In our example we would add 8 intercepts to the estimated parameters
  - these are for the 8 observed variables
  - by default, the two latent means are set at 0
  - The total number of estimated parameters = 17+8 = 25
- The total number of elements include the matrix of 36 + 8 observed means = 44
- The total degrees of freedom = 44 – 25 = 19
  - In this example the total degrees of freedom are the same with or without the mean structure (not always the case)
- Recommend reporting degrees of freedom without the mean structure unless you are modeling means

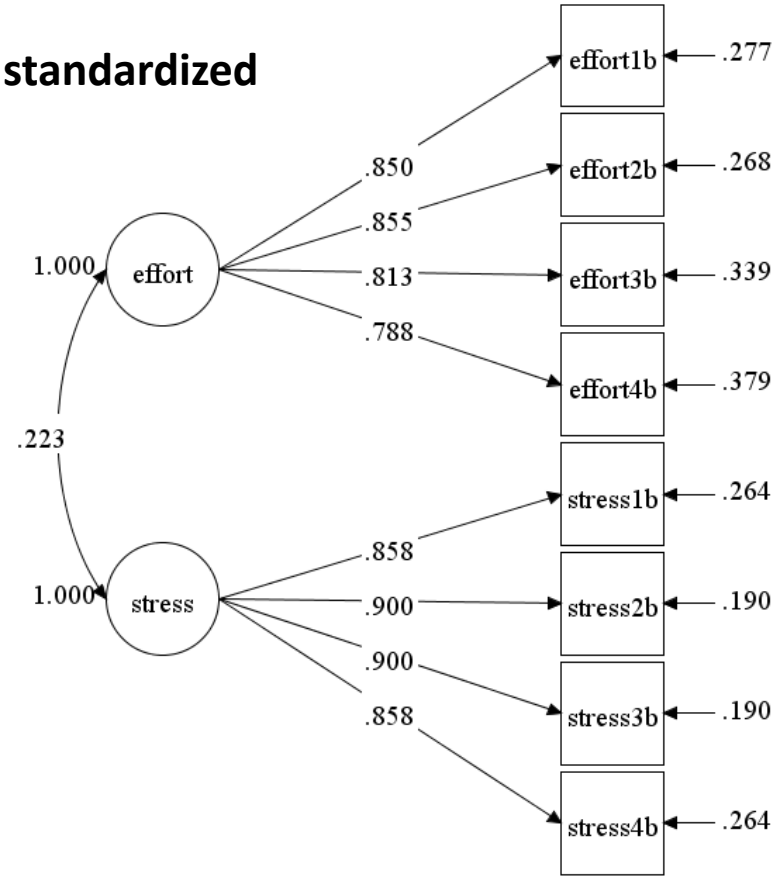
Example: CFA

```
usevariables are effort1b effort2b effort3b effort4b
stress1b stress2b stress3b stress4b;
model: Effort by effort1b effort2b effort3b effort4b;
Stress by stress1b stress2b stress3b stress4b;
output: sampstat stdyx;
```

unstandardized



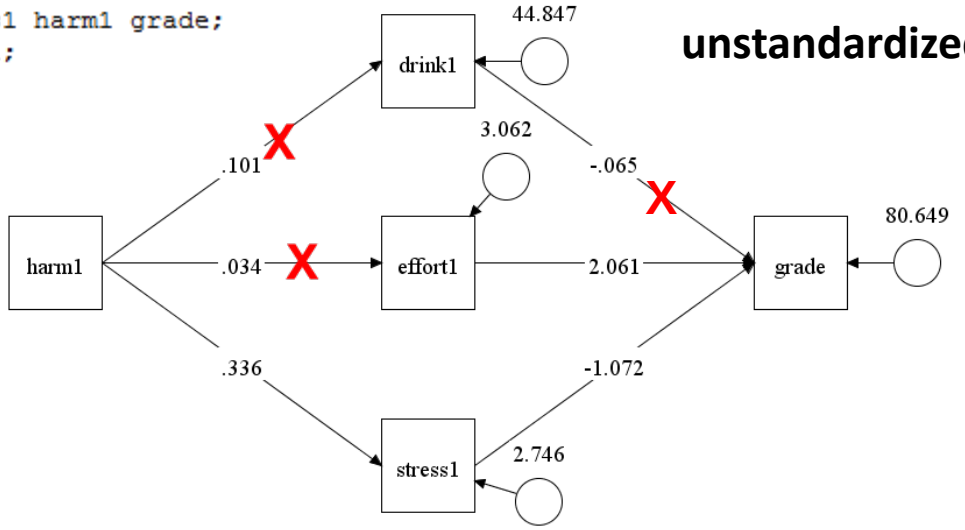
standardized



Example: Path Analysis

```
usevariables are drink1 effort1 stress1 harm1 grade;
model: grade on drink1 effort1 stress1;
stress1 effort1 drink1 on harm1;
output: sampstat stdyx;
```

unstandardized



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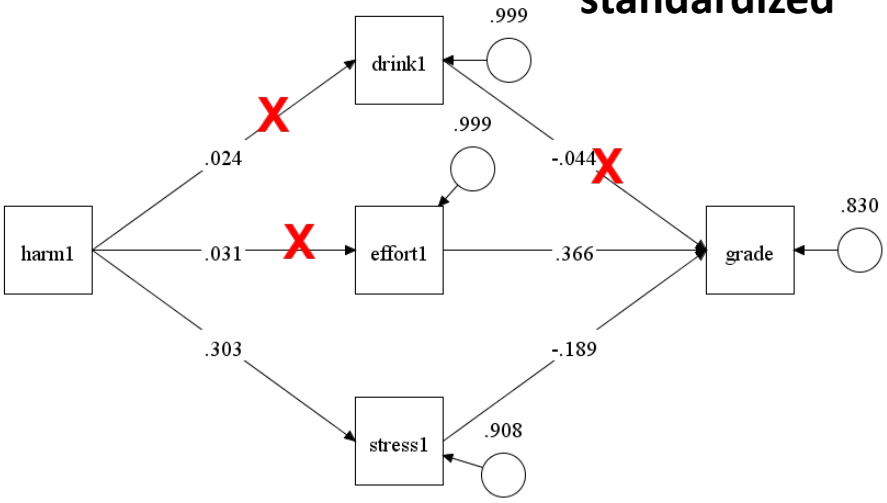
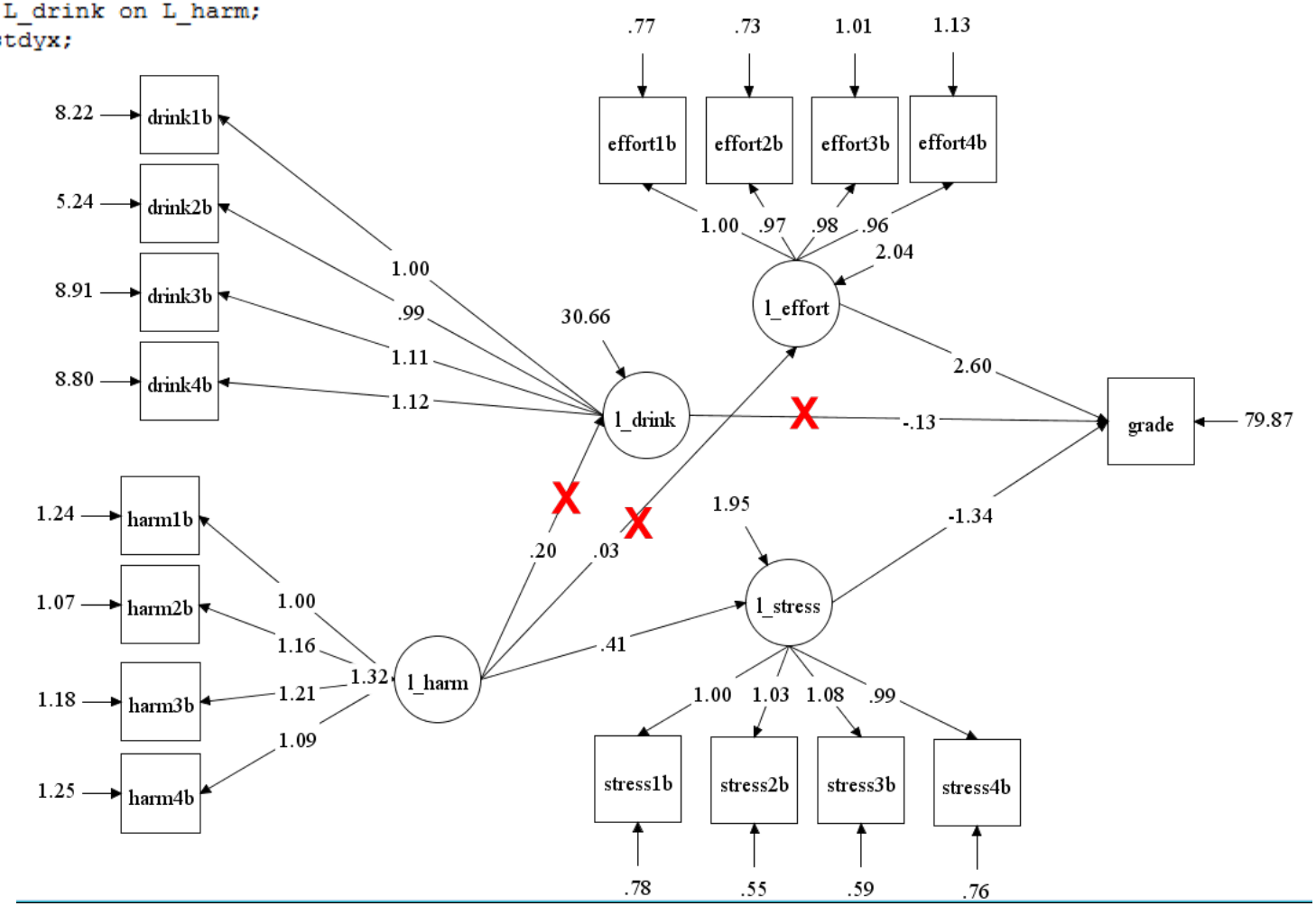


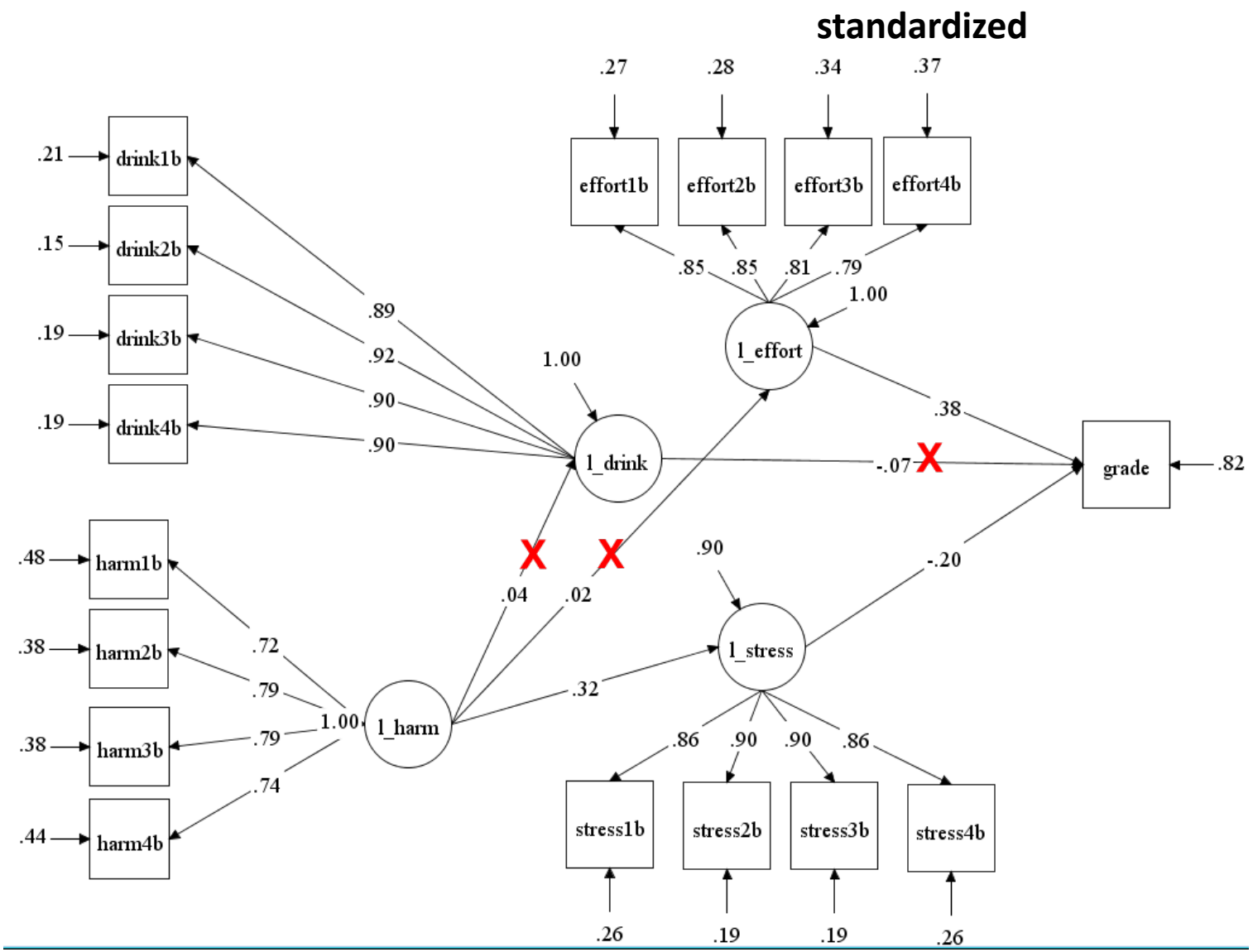
Example: Full SEM Model

```
model: L_effort by effort1b effort2b effort3b effort4b;
L_drink by drink1b drink2b drink3b drink4b;
L_harm by harm1b harm2b harm3b harm4b;
L_stress by stress1b stress2b stress3b stress4b;
grade on L_drink L_effort L_stress;
L_stress L_effort L_drink on L_harm;
output: sampstat stdyx;
```

unstandardized



Example: Full SEM Model



Steps in SEM

1. Background theoretical work
2. Specification
3. Identification (under identified, just-identified, over-identified)
4. Measure/variable selection and data collection (single vs. multiple indicators)
5. Estimation
6. Evaluate model fit and hypothesized parameters (effect size and statistical sig.)
7. Consider equivalent or similar models (e.g., number of factors)
8. Re-specify the model and re-run (estimation again)
9. Report results (keep track of all your modifications)
10. Replicate (especially when modifications have been made)

Steps in SEM: Why the two-step approach?

i.e., measurement model first, then inclusion of structural component

1. Reliability necessary pre-condition for valid inferences
2. Forces us to do measurement work
3. Separates measurement problems from structural problems
4. Provides feedback about model fit before including structural components:

   Assuming that you have included all variables in your measurement model as well as all the correlations between latent variables (and single observed variables), the model fit will not be improved once you include the structural component (to be discussed further in class)