Structural Equation Modeling and Higher Education

Elizabeth Davis, UNC School of the Arts
Kelly Smith, UNC School of the Arts / AEWAS Consulting

Structural Equation Modeling

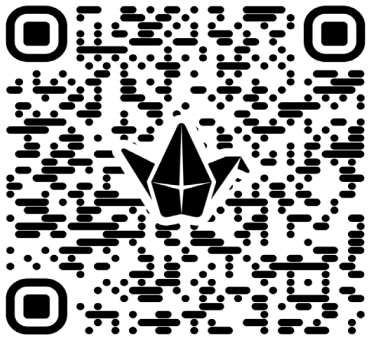
- Introduction
- SEM Comparison and Advantages
- Parts of SEM
- SEM in Higher Education

Are you being asked …

- … to answer more complex questions?
- … to answer questions that can't be answered with a "pure" qualitative or quantitative approach?
- … to answer questions that are looking for underlying structures instead of expected outcomes only?

Safe Share Experience …

- What questions are you being asked?
- Scan the QR code and share by clicking the green (+)



What is Structural Equation Modeling?

Integrates several multivariate statistical techniques into one dynamic modeling framework:

- Measurement theory
- Factor (latent variable) analysis
- Path Analysis
- Regression
- Simultaneous equations

AKA

- Covariance Structure Analysis Models
- analysis of moment structures
- LISREL Models
- Causal Modeling

Comparison of Multiple Regression and SEM

Multiple Regression Analysis

Process

- Identify variables of interest; check for missing data …
- Check variables for multicollinearity
- Calculate regression weights

Results

- Overall explanatory power of all the predictor variables (R^2)
- Individual predictors (βk)

Challenges

- Sensitive to measurement error
- Selection of independent variables is critical

Structural Equation Modeling

Process

- Confirmatory factor analysis
- Identify causal relationships among latent variables by path analysis

Results

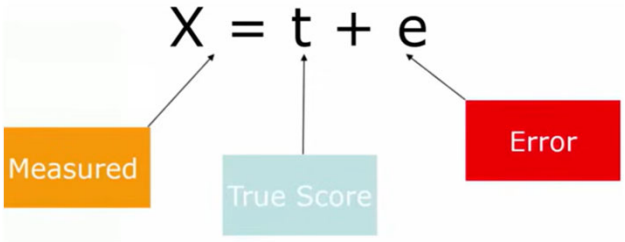
- Identify complex relationships among variables, including direct and indirect effects on variables and total effects on the outcome.

Challenges

- More complex analysis
- Requires large sample size
- Sample size determination

Advantages of Using SEM

- Corrects or reduces bias related to measurement error



- Flexible analysis method because you can have mediator variables and look at the indirect effects of variables in complex path models
- Allows for model fit

Basic SEM Models Include…

- Measurement of constructs: Confirmatory factor analysis
- Relationships between the constructs: Path analysis using latent variables

- In SEM we analyze the variance/ covariance matrix (*S*) of the observed variables, not the raw data.

- Our goal is to summarize *S* by specifying the underlying structure: the structural equation model.

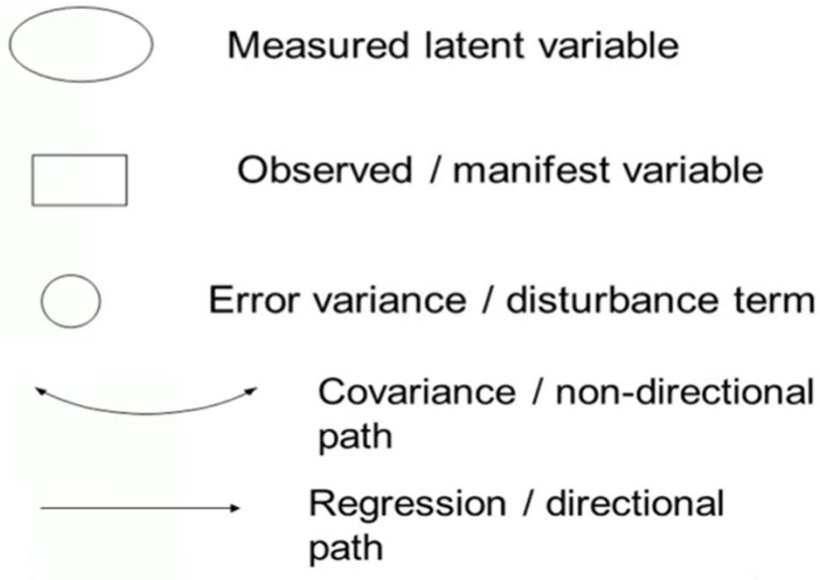
- SEM provides an implied matrix. Comparing *S* to the SEM tells us how well the model accounts for the data.
- Maximum Likelihood (ML) estimates model parameters by maximizing the likelihood of sample data

Confirmatory Factor Analysis

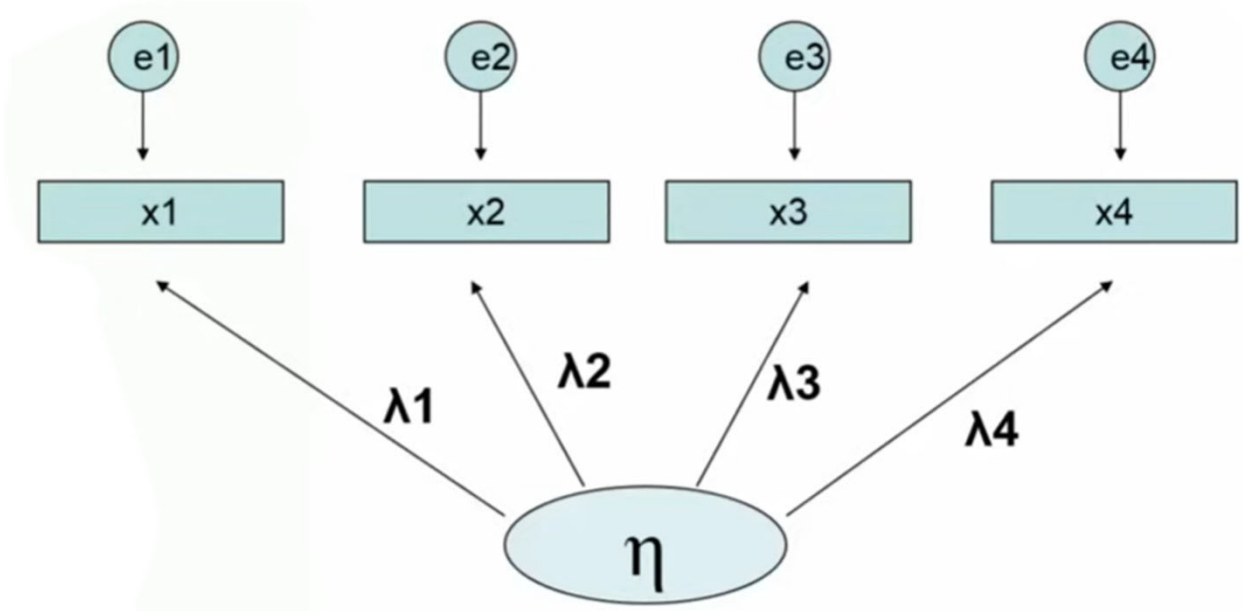
- Statistical method used to validate if survey or collected data matches your pre-specified factor structure (theory).
- Evaluates how well measured variables (indicators) represent a smaller number of latent constructs (factors)
- Used to determine if survey or collected data is measuring what it is supposed to (construct validity) and that the measurements are reliable

Path Analysis

- A diagram representation of a theoretical model using standardized notation
- Regression equations specified between measured variables
- “Effects” of predictor variables on dependent variables can be:
  - Direct
  - Indirect
  - Total

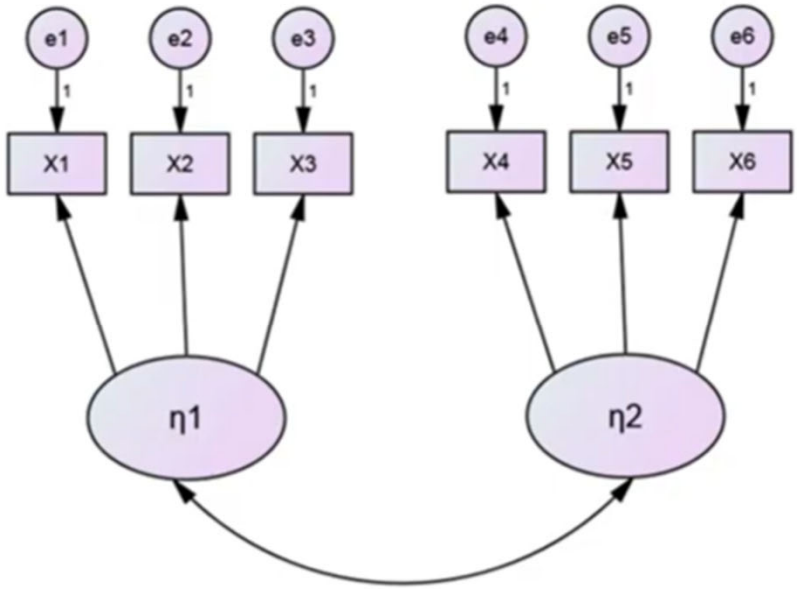


Example: Path Diagram with Latent Variable



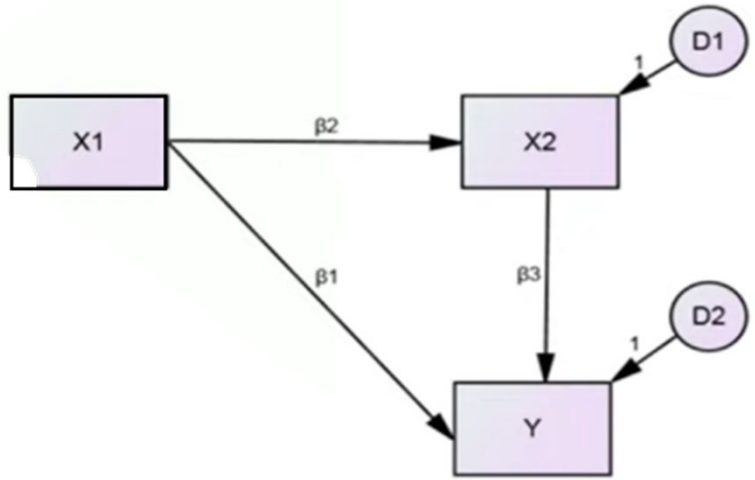
λ = Factor loadings = correlation between factor & indicator

Example: Path Diagram with 2 Correlated Latent Variables



2 latent variables, each measured by 3 observed variables

Example: Path Diagram with Indirect Effect



β1=direct effect of X1 on Y

β2=direct effect of X1 on X2

β3=direct effect of X2 on Y

β2*β3=indirect effect of X1 on Y

β1+(β2*β3)=total effect of X1 on Y

SEM Research Questions

- Allows researchers to test theories to advance understanding of relationships:
  - Are complex, multifaceted, and hard to measure and/ or there are measurement errors such as social psychological concepts
  - Involve systems of relationships multiple dependent variables and predictors such as causal systems
  - Focus on indirect effects as well on direct variables on other variables

SEM in Research

STUDENTS	INSTITUTIONS*	SYSTEMS / POLICY
Self-efficacy	Timely Transfers	System Performance
Experiences / Perceptions	High Impact Practices	
Learning	Online Learning	
Post-Graduation Success	Collaborative Learning	
	STEM Courses	
	Institutional Reputation	
	Retention/ Completion	

* Community Colleges, University Undergraduate and Graduate

Example: Cabrera, A., Nora, A., Castañeda, M. (1993): College Persistence: Structural Equations Modeling Test of an Integrated Model of Student Retention

Research Question	Data Sources	Population	Factors	Outcome
To what extent can Tinto's Student Integration Theory be merged with Bean's Student Attrition Model to explain student persistence decisions?	Questionnaire, spring and fall transcripts	1988 entering first-time freshman at a large southern urban institution traditional students, who were United States citizens or permanent residents, under twenty-four years of age, and not married	- Finance Attitudes - Encouragement from Friends and Family - Academic Integration - Academic Performance (GPA) - Social Integration - Institutional Commitment - Goal Commitment - Intent to Persist - Persistence	- Persistence as measured by re-enrollment in the institution in the fall

Cabrera & Castañeda: Hypothesized Model of Student Persistence

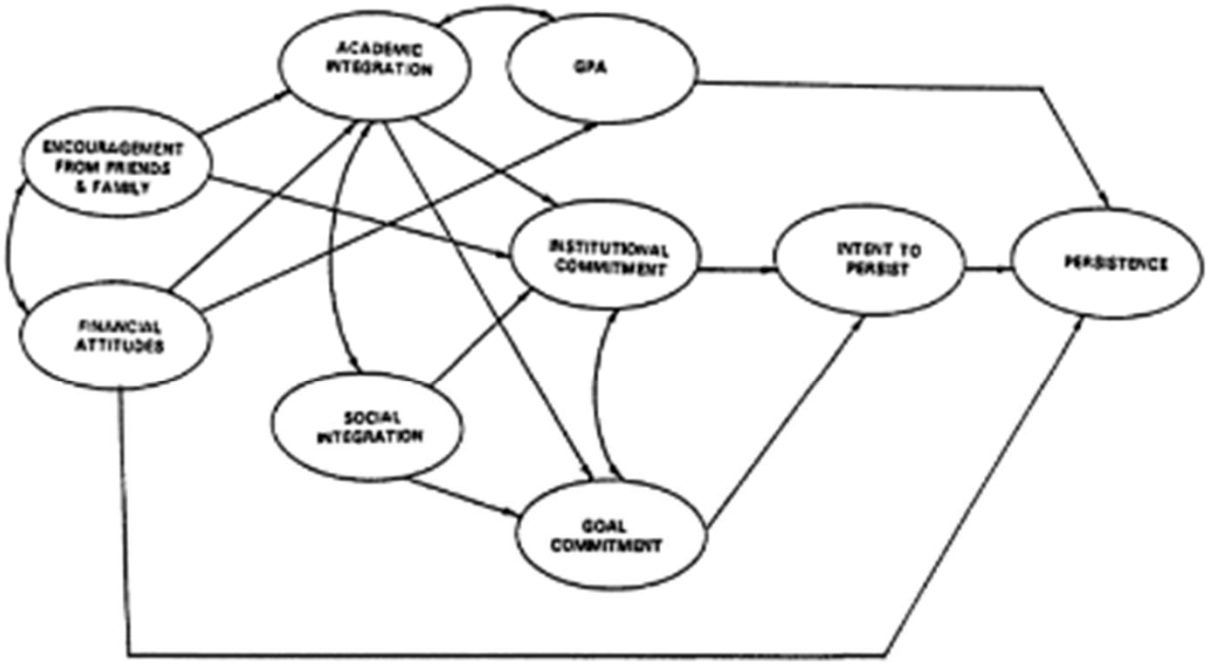


FIG. 1. Hypothetical Model

Cabrera & Castañeda, M. (1993): Factors and Variables

Factors	Variables
- Finance Attitudes	- I am satisfied with the amount of financial support (grants, loans, family, jobs) I have received while attending …
- Encouragement from Friends and Family	- My family approves of me attending … - My family encourages me to continue attending … - My close friends encourage me to continue attending …
- Academic Integration	- I have performed academically as well as I anticipated I would - I am satisfied with the course curriculum - I am satisfied with my academic experience
- Academic Performance (GPA)	- Cumulative average GPA at the end of spring
- Social Integration	- Since coming to university I have developed close personal relationships with other students - It has been easy for me to meet and make friends with other students at university
- Institutional Commitment	- I am confident I have made the right decision in choosing to attend... - Composite average score of: 1) It is important for me to graduate from [institution] as opposed to some other school; 2) I feel I belong at…; 3) My education at [institution] will help me secure future employment; 4) My close friends rate [institution] as a quality institution
- Goal Commitment	- It is important for me to get a college degree - It is important for me to complete my program of study
- Intent to Persist	- It is likely I will re-enroll at [institution] next fall
- Persistence	- Student's enrollment status in fall 1989

Cabrera & Castañeda: Final Structural Model and Total Effects

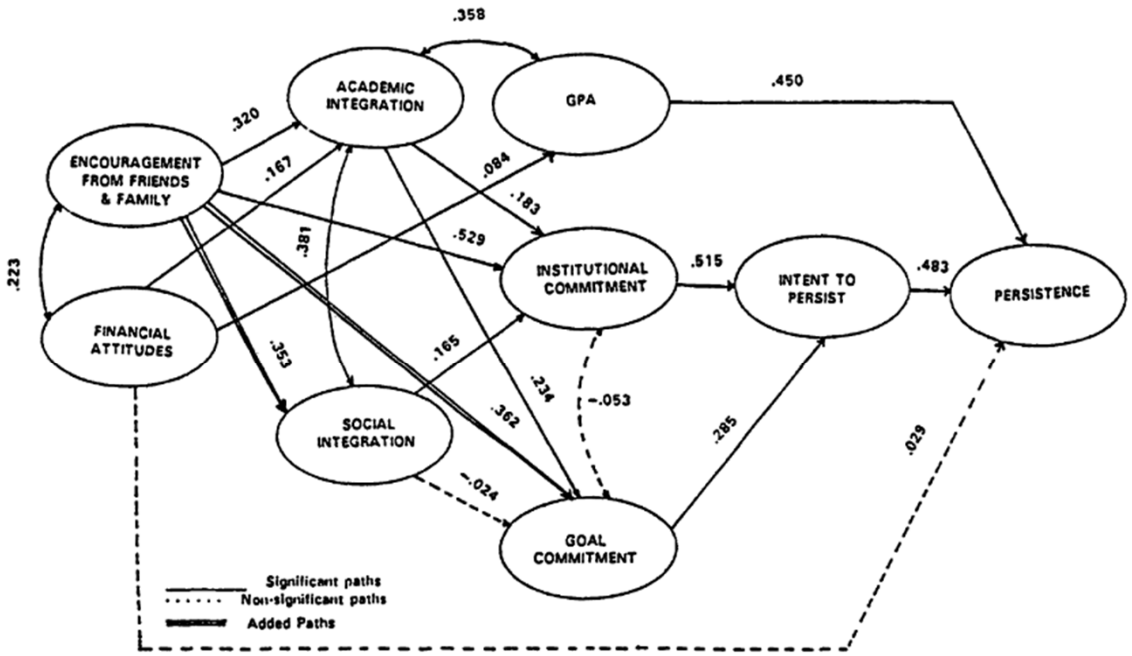


FIG. 3. Final Structural Model

TABLE 3
Total Effects on Persistence and Intent to Persist

	Persistence Behavior		Intent to Persist	
Variable	Total Effect	Rank	Total	Rank
Finance Attitudes	0.054	7	0.026	6
Encouragement	0.217	4	0.447	2
Academic Integration	0.083	6	0.171	4
GPA	0.463	2	0.000	
Social Integration	0.046	8	0.094	5
Institutional Commitment	0.273	3	0.562	1
Goal Commitment	0.133	5	0.274	3
Intent to Persist	0.485	1	0.000	

Could I use SEM?

- Do I have multiple indicators?
- Will I have a large enough sample size?
  - Literature suggests that 200 is a good starting point but encourage the use of Monte Carlo Simulations to construct a model based on your specifications and then test the model on “random” datasets of varying sample sizes
- How reliable are my measures?
- Will I have multiple dependent and/ or mediator variables?

Software Packages

- AMOS (SPSS)
- PROC CALIS (SAS) and JMP (SAS interface)
- SEM (Stata)
- SEPATH (Statistica)
- Stand-alone software
  - EQS
  - LISREL
  - M*plus*
  - OpenMX
  - R

Potential Research Projects

Research Projects	Theoretical Framework
Enrollment, Retention, and Completion • Criteria only available during admissions process • Enrolled student data	Bean: Conceptual Model of Dropout Syndrome (1985). Bean and Metzner: Conceptual Model of Nontraditional Student Attrition (1985). Pascarella: Conceptual Model for Research on Student-Faculty Informal Contact (1980) Tinto: Longitudinal Model of Institutional Departure (1973/ 1993). Tinto: Model of the Longitudinal Process of Persistence (2025).
Institutional performance as compared to peer institutions (SACSCOC Standard 8.1- Student Achievement).	Astin: Input-Environment-Output (IEO) Model (1970)

Resources

National Centre for Research Methods (NCRM). Structural Equation Modeling Playlist (6 videos- ~2.5 total) hours). https://tinyurl.com/mskade2s

Nusair, K., & Hua, N. (2010). Comparative assessment of structural equation modeling and multiple regression research methodologies: E-commerce context. *Tourism management*, *31*(3), 314-324.

QuantFish. SEM for Beginners Playlist (33 videos). https://tinyurl.com/9x2xmk7x

Whittaker, T. A. & Schumacker, R. E. (2022). *Beginner's Guide to Structural Equation Modeling (5th ed)*. Routledge. https://tinyurl.com/mpsej34t

Wolf, E. J., Harrington, K. M., Clark, S. L., & Miller, M. W. (2013). Sample Size Requirements for Structural Equation Models: An Evaluation of Power, Bias, and Solution Propriety. *Educational and psychological measurement*, *76*(6), 913–934. https://doi.org/10.1177/0013164413495237

Thank you!

- Slides?
- Thoughts?
- Suggestions?

- Please reach out …

davisel@uncsa.edu
smithke@uncsa.edu
kds.aewas@gmail.com

What is SEM Used for?

- Examples from higher education literature include:
  - Calaguas, N. P., & Consunji, P. M. P. (2022). A structural equation model predicting adults' online learning self-efficacy. *Education and Information Technologies*, *27*(5), 6233-6249.
  - Wu, X. Y. (2025). Exploring the impact of blended collaborative learning on deep learning outcomes: a structural equation modeling approach. *Education and Information Technologies*, *30*(10), 13411-13437.
  - Amado, M., Guzmán, A., & Juarez, F. (2023). Relationship between perceived value, student experience, and university reputation: structural equation modeling. *Humanities and Social Sciences Communications*, *10*(1), 1-13.
  - Mosia, M., Egara, F. O., Nannim, F. A., & Basitere, M. (2025). Factors influencing students' performance in university mathematics courses: A structural equation modelling approach. *Education Sciences*, *15*(2), 188.
  - Agasisti, T., & Bertoletti, A. (2019). Analysing the determinants of higher education systems' performance–a structural equation modelling approach. *Science and Public Policy*, *46*(6), 834-852.
  - Dickert, J. L., & Li, J. (2024). Illuminating the post-graduation impact of undergraduate participation in high-impact practices using propensity score analysis with structural equation modeling. *Research in Higher Education, 65*(5), 943-964. https://doi.org/10.1007/s11162-023-09767-2
  - From Aspirations to Actualization: How Engagement With Supports, Networks and Services Influence Community College STEM Students' Self-Efficacy and Timely Transfer (2026)
  - Upward Transfer Student Pathways in Computing: Examining Degree and Career Outcomes (2025)
  - Unraveling the factors shaping academic success (2024)
  - University students' academic resilience academic well-being, personality and educational attainment in online classes (2023)
  - Investigating Graduate Students' Experiences (2023)