

**Psychological and Quantitative Foundations (PSQF) 6249 Section 0002:  
Factor Analysis and Structural Equation Models Fall 2022**

Instructor and Home Department Information:	<b>Professor Lesa Hoffman (she/her—you can call me Lesa)</b> Educational Measurement and Statistics Program <i>PSQF Dept Office: South 361 Lindquist Center; DEO: Professor Saba Ali</i>
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Zoom Link for Class and Office Hours:	<a href="https://uiowa.zoom.us/my/lesahoffmaniowa">https://uiowa.zoom.us/my/lesahoffmaniowa</a> Meeting ID: 5044356512; Mobile Access: +13126266799
Course Location and Time:	166 North Lindquist Center or via zoom Tuesdays and Thursdays 2:00–3:15 PM
Zoom-Only Office Hours:	Mondays and Wednesdays 3:30–4:30 PM in a group format or individually by appointment

**Schedule of Topics and Events:**

This course will meet **synchronously in person and on zoom**. The planned schedule of topics and events given here will likely need to be adjusted throughout the course. The **course website** will always have the **most current schedule of events and due dates**: <http://www.lesahoffman.com/PSQF6249/index.html>

**Course Objectives, Pre-Requisites, and Materials:**

The course objective is for participants to be able to understand and implement contemporary approaches to measurement, expanding from classical test theory into measurement models for latent traits (i.e., confirmatory factor models, item response models) and their use within structural equation models. In addition to these statistical models, the course will also focus on the measurement concepts behind these models and how they relate to each other with respect to scale construction and evaluation. Prior to enrolling, participants should be comfortable with general linear models (e.g., regression, ANOVA).

Class time will be devoted primarily to lectures, examples, and spontaneous review, the materials for which will be available for download at the course website. Readings and other resources have been suggested for each topic and may be updated later. Synchronous attendance (in person or via zoom) is encouraged but not required, and you do not need to notify the instructor of a single class absence. Video recordings of each class will be made available on YouTube so that closed captioning will be provided, and supplemental videos for specific topics (e.g., software demos) may be added as well. Auditors and visitors are always welcome to attend class. No required class sessions will be held outside the regular class time given above (i.e., no additional midterm or final exam sessions). However, because the course will have an applied focus requiring the use of statistical software, participants are encouraged to attend group-based office hours (via zoom only), in which multiple participants can receive immediate assistance on homework assignments simultaneously.

**Course Requirements:**

Participants will have the opportunity to earn **up to 100 total points** by completing work outside of class. Up to **90 points** can be earned from **homework assignments** (approximately 6 in total)—these will be graded for accuracy. Homework assignments that involve **individual writing** will have the opportunity to be **revised once** to earn the maximum total points. **Written assignments must be at least ¾ complete to be accepted**. Unless otherwise instructed, please use “track changes” and retain all original instructor comments so that the instructor can easily see how your revisions address the comments.

Up to **10 points** may be earned from submitting **formative assessments** (approximately 5 in total) through ICON; these will be graded for effort only—incorrect answers will not be penalized. Participants may earn up to **2 extra credit points** for completing homework 0; there may be other opportunities to earn extra credit at the instructor's discretion. Finally, revisions to the planned course schedule and/or content may result in fewer homework assignments and formative assessments (and thus fewer total points) at the instructor's discretion.

### Policy on Accepting Late Work and Grades of Incomplete:

Participants may submit work at any point during the semester to be counted towards their course grade. However, in order to encourage participants to keep up with the class, **late homework assignments will incur a 2-point penalty; late revisions or late formative assessments will incur a 1-point penalty.** Extensions will be granted as needed for extenuating circumstances (e.g., conferences, comprehensive exams, family obligations) if requested at least two weeks in advance of the due date. A final grade of "incomplete" will only be given in dire circumstances and entirely at the instructor's discretion. **All work must be submitted by Friday, May 16, 2022, at 5:00 PM to be included in the course grade.**

### Final grades will be determined by the *percentage* earned out of the total possible points:

>96% = A+, 93–96% = A, 90–92% = A–, 87–89% = B+, 83–86% = B, 80–82% = B–, 77–79% = C+, 73–76% = C, 70–72% = C– (**PASS**), 67–69% = D+, 63–66% = D, 60–62% = D–, <60% = F

### Course Software:

Participants will need to have access to statistical software—**Mplus or R+Rstudio**—that can estimate the models presented. Each of these programs are freely available to course participants in multiple ways:

- You can connect to the [U Iowa Virtual Desktop](#) (connect to the [U Iowa VPN](#) first) for free
- You can [install R software](#) for free on your local machine, along with the free [graphical Rstudio interface](#) that makes R easier to use (install second after R software)
- You could also pay [\\$195 for a student license](#) for the base version of Mplus

### Course Textbook:

Brown, T. A. (2015). *Confirmatory factor analysis for applied research* (2<sup>nd</sup> ed). Guilford. Available at the [University of Iowa library in electronic form](#).

### Other Course Readings (all available in [ICON](#) under “Files”):

**Note—I know this is A LOT of readings, but we are covering a lot of material! I have included these sources to give you some additional background and/or exposure to current best-practices in each topic. I encourage you to read as much as possible, but your priority should be to participate in class and complete course work first!**

Asparouhov, T. & Muthén, B. (2014) Multiple-group factor analysis alignment. *Structural Equation Modeling*, 21(4), 495–508. <https://doi.org/10.1080/10705511.2014.919210>

Bandalos, D. L. (2021). Item meaning and order as causes of correlated residuals in confirmatory factor analysis. *Structural Equation Modeling*, 28(6), 903–913. <https://www.tandfonline.com/doi/full/10.1080/10705511.2021.1916395>

Bauer, D. J., & Hussong, A. M. (2009). Psychometric approaches for developing commensurate measures across independent studies: Traditional and new models. *Psychological Methods*, 14(2), 101–125. <https://psycnet.apa.org/doi/10.1037/a0015583>

Bollen, K. A., & Diamantopoulos, A. (2017). In defense of causal-formative indicators: A minority report. *Psychological Methods*, 22(3), 581–596. <https://psycnet.apa.org/doi/10.1037/met0000056>

- Chen, F., F., West, S. G., & Sousa, K. H. (2006). [A comparison of bifactor and second-order models of quality of life](#). *Multivariate Behavioral Research*, 41(2), 189–225.
- Clifton, J. D. W. (2020). Managing validity versus reliability trade-offs in scale-building decisions. *Psychological Methods*, 25(3), 259–270. <https://doi.org/10.1037/met0000236>
- Cole, D. A., & Preacher, K. J. (2014). Manifest variable path analysis: potentially serious and misleading consequences due to uncorrected measurement error. *Psychological Methods*, 19(2), 300–315. <https://psycnet.apa.org/doi/10.1037/a0033805>
- Curran, P. J., Cole, V. T., Bauer, D. J., Rothenberg, W. A., & Hussong, A. M. (2018). Recovering predictor–criterion relations using covariate-informed factor score estimates. *Structural Equation Modeling*, 25(6), 860–875. <https://doi.org/10.1080/2F10705511.2018.1473773>
- Curran, P. J., McGinley, J. S., Bauer, D. J., Hussong, A. M., Burns, A., Chassin, L., Sher, K., & Zucker, R. (2014). A moderated nonlinear factor model for the development of commensurate measures in integrative data analysis. *Multivariate Behavioral Research*, 49(3), 214–231. <https://doi.org/10.1080/00273171.2014.889594>
- Davidson, C. A., Hoffman, L., & Spaulding, W. D. (2016). Schizotypal personality questionnaire – brief revised (updated): An update of norms, factor structure, and item content in a large non-clinical young adult sample. *Psychiatry Research*, 238, 345–355. <https://doi.org/10.1016/j.psychres.2016.01.053>
- Edwards, M. C., & Wirth, R. J. (2009). Measurement and the study of change. *Research in Human Development*, 62(2–3), 74–96. <https://psycnet.apa.org/doi/10.1080/15427600902911163>
- Embretson, S. E., & Reise, S. T. (2000). *Item response theory for psychologists*. Erlbaum.
- Enders, C. K. (2010). *Applied missing data analysis*. Guilford.
- Feng, Y., & Hancock, G. R. (2023). Power analysis within a structural equation modeling framework. In R. H. Hoyle (Ed.) *Handbook of structural equation modeling* (2<sup>nd</sup> ed.), pp. 163–183. Guilford Press.
- Ferrando, P. J. (2009). Difficulty, discrimination, and information indices in the linear factor analysis model for continuous item responses. *Applied Psychological Measurement*, 33(1), 9–24. <https://doi.org/10.1177%2F0146621608314608>
- Gonzales, O., Valente, M. J., Cheong, J., & MacKinnon, D. P. (2023). Mediation/indirect effects in structural equation modeling. In R. H. Hoyle (Ed.) *Handbook of structural equation modeling* (2<sup>nd</sup> ed.), pp. 409–426. Guilford Press.
- Gunn, H. J., Grimm, K. J., & Edwards, M.C. (2020). Evaluation of six effect size measures of measurement non-invariance for continuous outcomes. *Structural Equation Modeling*, 27(4), 503–514. <https://doi.org/10.1080/10705511.2019.1689507>
- Henninger, M., & Meiser, T. (2020). Different approaches to modeling response styles in divide-by-total item response theory models (part 1): A model integration. *Psychological Methods*, 25(5), 560–576. <https://doi.org/10.1037/met0000249>
- Henninger, M., & Meiser, T. (2020). Different approaches to modeling response styles in divide-by-total item response theory models (part 2): Applications and novel extensions. *Psychological Methods*, 25(5), 577–595. <https://doi.org/10.1037/met0000268>
- Huggins-Manley, A. C., Algina, J. & Zhou, S. (2018). Models for semiordeered data to address not applicable responses in scale measurement. *Structural Equation Modeling*, 25(2), 230–243. <https://doi.org/10.1080/10705511.2017.1376586>
- John, O. P., & Benet-Martinez, V. (2014). [Measurement: Reliability, construct validation, and scale construction](#). In H. T. Reis & C. M. Judd (Eds.), *Handbook of research methods in social and personality psychology* (pp. 473-503, 2<sup>nd</sup> ed.). Cambridge University Press.

- Magnus, B. E., & Liu, Y. (2022). Symptom presence and symptom severity as unique indicators of psychopathology: An application of multidimensional zero-inflated and hurdle graded response models. *Educational and Psychological Measurement*, 82(5), 938–966.  
<https://doi.org/10.1177/00131644211061820>
- Maydeu-Olivares, A. (2015). [Evaluating the fit of IRT models](#). In S. P. Reise & D. A. Revicki (Eds.), *Handbook of item response theory modeling* (pp. 111–127). Taylor & Francis.
- McDonald, R. P. (1999). *Test theory: A unified treatment*. Erlbaum.
- McNeish, D. (2018). Thanks coefficient alpha, we'll take it from here. *Psychological Methods*, 23(3), 412–433. <https://doi.org/10.1037/met0000144>
- McNeish, D. & Wolf, M G. (2020). Thinking twice about sum scores. *Behavior Research Methods*, 52(6), 2287–2305. <https://doi.org/10.3758/s13428-020-01398-0>
- Mungas, D., & Reed, B. R. (2000). Application of item response theory for development of a global functioning measure of dementia with linear measurement properties. *Statistics in Medicine*, 19(11–12), 1631–1644. [https://doi.org/10.1002/\(sici\)1097-0258\(20000615/30\)19:11/12%3C1631::aid-sim451%3E3.0.co;2-p](https://doi.org/10.1002/(sici)1097-0258(20000615/30)19:11/12%3C1631::aid-sim451%3E3.0.co;2-p)
- Ostini, R., & Nering, M. (2006). *Polytomous item response theory models*. Sage. Available at the [University of Iowa library in electronic form](#).
- Paek, I., Cui, M., Gübes, N. O., & Yang, Y. (2018). Estimation of an IRT model by Mplus for dichotomously scored responses under different estimation methods. *Educational and Psychological Measurement*, 78(4), 569–588. <https://doi.org/10.1177%2F0013164417715738>
- Preacher, K. J., & MacCallum, R. C. (2003). Repairing Tom Swift's electric factor analysis machine. *Understanding Statistics*, 2(1), 13–43. [https://doi.org/10.1207/S15328031US0201\\_02](https://doi.org/10.1207/S15328031US0201_02)
- Reise, S. P., Mansolf, M. & Haviland, M. G. (2023). Bifactor measurement models. In R. H. Hoyle (Ed.) [Handbook of structural equation modeling](#) (2<sup>nd</sup> ed.), pp. 329–348. Guildford Press.
- Revuelta, J., Maydeu-Olivares, A., & Ximénez, C. (2020). Factor analysis for nominal (first choice) data. *Structural Equation Modeling*, 27(5), 781–797.  
<https://psycnet.apa.org/doi/10.1080/10705511.2019.1668276>
- Rohrer, J. M., Hünermund, P., Arslan, R. C., & Elson, M. (2022). That's a lot to process! Pitfalls of popular path models. *Advances in Methods and Practices in Psychological Science*, 5(2), 1–14.  
<https://doi.org/10.1177%2F25152459221095827>
- Sterba, S. K., & Rights, J. D. (2023). Item parceling in SEM: A researcher degree-of-freedom ripe for opportunistic use. In R. H. Hoyle (Ed.) [Handbook of structural equation modeling](#) (2<sup>nd</sup> ed.), pp. 296–315. Guildford Press.
- Tay, L., & Jebb, A. T. (2018). Establishing construct continua in construct validation: The process of continuum specification. *Advances in Methods and Practices in Psychological Science*, 1(3), 375–388. <https://doi.org/10.1177%2F2515245918775707>
- Vandenberg, R. J., & Lance, C. E. (2000). A review and synthesis of the measurement invariance literature: Suggestions, practices, and recommendations for organizational research. *Organizational Research Methods*, 3(1), 4–69. <https://doi.org/10.1177%2F109442810031002>
- West, S. G., Wu, W., McNeish, D., & Savord, A. (2023). Model fit in structural equation modeling. In R. H. Hoyle (Ed.) [Handbook of structural equation modeling](#) (2<sup>nd</sup> ed.), pp. 184–285. Guildford Press.
- Wirth, R. J., & Edwards, M. C. (2007). Item factor analysis: Current approaches and future directions. *Psychological Methods*, 12(1), 58–79. <https://doi.org/10.1037/1082-989x.12.1.58>
- Zhang, X., Zhou, L., & Savalei, V. (2022). Comparing the psychometric properties of a scale across three likert and three alternative formats: An application to the Rosenberg Self-Esteem Scale. Online advance publication in *Educational and Psychological Measurement*.  
<https://doi.org/10.1177/00131644221111402>

### Academic Misconduct:

As a reminder, the University of Iowa College of Education has a [formal policy on academic misconduct](#), which all students in this course are expected to follow. While students can work with each other to understand the course content, all homework assignments must ultimately be completed individually. Please consult the instructor if you have questions.

### Respect for Each Other:

The instructor wants ALL students to feel welcome and encouraged to participate in this course. **There is no such thing as a “stupid” question (or answer).** All course participants—enrolled students and auditing visitors—should always feel welcome to ask whatever questions will be helpful in helping them understand the course content. **Questions or comments are welcome at any point** during class (aloud or using the zoom chat window), in office hours, over email, or in individual appointments with the instructor (available by request). Students with disabilities or who have any special needs are encouraged to contact the instructor for a confidential discussion of their individual needs for academic accommodation.

**All participants are welcome to attend class via zoom instead of in person for any reason at any time.** If you do attend class in person, the University of Iowa encourages everyone to be vaccinated against COVID-19 and to wear a face mask in all classroom settings. **If it possible that you have been exposed to COVID-19 or any other illness, please DO NOT attend class in person!** Similarly, if the instructor has been exposed to illness or the weather prohibits safe travel to class, the course will move to a temporary zoom-only format to protect all course participants. **When using zoom, please provide the name you wish for us to call you inside your zoom account** (i.e., so that it appears on your window while in use). Student use of cameras and microphones while on zoom is also encouraged but not required (out of respect for your privacy and/or limited bandwidth). Please note that class video recordings posted on YouTube will NOT include any video from course participants (only the class audio and screen share from the instructor will be captured). Participants who do not wish for their audio to be captured can use the zoom chat window (which also allows for private direct messages to the instructor), even while attending in person.

The University of Iowa is committed to **making the class environment (in person or online) a respectful and inclusive space** for people of all gender, sexual, racial, religious, and other identities. Toward this goal, students are invited to optionally share the names and pronouns they would like their instructors to use to address them. The University of Iowa prohibits discrimination and harassment against individuals on the basis of race, class, gender, sexual orientation, national origin, and other identity categories. For more information, contact the [Office of Institutional Equity](#). Additional university guidelines about classroom behavior and other student resources [are provided here](#), student complaint procedures [are provided here](#), and the university acknowledgement of land and sovereignty is [here](#).

### Respect for The Rest of Your World:

The instructor realizes that this course is not your only obligation in your work or your life. While class attendance in real time is not mandatory, it is strongly encouraged because frequent review of the material will be your best strategy for success in this course. However, if work or life events may compromise your ability to succeed, please contact the instructor for a confidential discussion so that we can work together to make a plan for your success. **Please do not wait until you are too far behind to try to catch up!**

**Schedule of Events for Weeks 1–7:**

<b>Week Number</b>	<b>Weekday and Date</b>	<b>Topics</b>	<b>Readings for Each Topic</b>
1	M 8/22	<b>NO OFFICE HOURS TODAY NO HOMEWORK (HW) OR FORMATIVE ASSESSMENT (FA) DUE</b>	
	T 8/23	Lecture 1: Introduction to this Course and to Latent Trait Measurement Models	Brown (2015) ch. 1
	R 8/25	Lecture 1, continued	John & Benet-Martinez (2014)
2	M 8/29	<b>HW0 (for 2 points extra credit) DUE ONLINE BY 11:59 PM</b>	
	T 8/30	Lecture 1, continued Lecture 3: Classical Test Theory for Scale Reliability	McDonald (1999) ch. 5-7
	R 9/1	Lecture 3, continued Example 3: Classical Items Analysis	McNeish (2018) Clifton (2020)
3	M 9/5	<b>NO HW OR FA DUE</b>	
	T 9/6	<b>OFFICE HOURS TUESDAY 9/6 INSTEAD OF MONDAY 9/5</b> Lecture 4: Confirmatory Factor Analysis	Brown (2015) ch. 3-5
	R 9/8	<b>MEET ON ZOOM ONLY OFFICE HOURS THURSDAY 9/8 INSTEAD OF WEDNESDAY 9/7</b> Lecture 4, continued	Ferrando (2009) West et al. (in press)
4	M 9/12	<b>FA1 DUE VIA ICON BY 11:59 PM</b>	
	T 9/13	Lecture 4, continued Example 4: Confirmatory Factor Models in Mplus (and SAS MIXED)	McNeish & Wolf (2020)
	R 9/15	Lecture 4 and Example 4, continued	Bollen & Diamantopoulos (2017)
5	M 9/19	<b>HW1 DUE VIA ICON BY 11:59 PM: Instrument Background</b>	
	T 9/20	Lecture 4 and Example 4, continued	Enders (2010) ch. 3-5
	R 9/22	Lecture 4 and Example 4, continued	
6	M 9/26	<b>FA2 DUE VIA ICON BY 11:59 PM</b>	
	T 9/27	Lecture 4 and Example 4, continued	
	R 9/29	Lecture 4 and Example 4, continued	
7	M 10/3	<b>NO HW OR FA DUE</b>	
	T 10/4	Lecture 5: Latent Trait Measurement Models for Binary Responses	Embretson & Reise (2000) ch. 2-4, 7-8 Mungas & Reed (2000)
	R 10/6	<b>MEET ON ZOOM ONLY</b> Lecture 5 and Example 5, continued	Wirth & Edwards (2007)



**Schedule of Events for Weeks 8–12:**

<b>Week Number</b>	<b>Weekday and Date</b>	<b>Topics</b>	<b>Readings for Each Topic</b>
8	M 10/10	<b>HW2 DUE ONLINE BY 11:49 PM: Practice with CFA</b>	Maydeu-Olivares (2015) Paek et al. (2018)
	T 10/11	Lecture 5, continued	
	R 10/13	<b>NO CLASS 10/13 OR OFFICE HOURS 10/12</b> <i>Material to review on your own:</i> Lecture 2 videos from the previous version of this class Lecture videos for PCA and EFA by Jonathan Templin (under "Files" in ICON)	Brown (2015) ch. 2 Preacher & McCollum (2003)
9	M 10/17	<b>FA3 DUE VIA ICON BY 11:59 PM</b> <b>OPTIONAL REVISION TO HW1 DUE VIA ICON BY 11:59 PM</b>	
	T 10/18	<b>MEET ON ZOOM ONLY</b> Lecture 5, continued Example 5: Binary Item Response Models in Mplus	
	R 10/20	<b>MEET ON ZOOM ONLY</b> Lecture 5 and Example 5, continued	
10	M 10/24	<b>HW3 DUE VIA ICON BY 11:59 PM: CFA on Your Own Data</b>	
	T 10/25	Lecture 5 and Example 5, continued	
	R 10/27	Lecture 5 and Example 5, continued  Lecture 6: Latent Trait Measurement Models for Other Item Responses Example 6a: Graded Response Models for Ordinal Responses in Mplus  Bonus material: Example 6b: Measurement Models for Semi-Ordered (Not Applicable) Responses in Mplus Example 6c: Measurement Models for Other Non-Normal Outcomes in Mplus	
11	M 10/31	<b>FA4 DUE VIA ICON BY 11:59 PM</b>	
	T 11/1	Lecture 6 and Example 6a, continued	
	R 11/3	Lecture 6 and Example 6a, continued	
12	M 11/7	<b>NO HW OR FA DUE</b>	Brown (2015) ch. 7 Vandenberg & Lance (2000) Gunn et al. (2020) Asparouhov & Muthén (2014)
	T 11/8	Lecture 7: Measurement Invariance in CFA and Differential Item Functioning in IRT/IFA	
	R 11/10	Lecture 7, continued Example 7a: Multiple-Group Measurement Invariance in CFA using Mplus	

**Schedule of Events for Weeks 13–17:**

<b>Week Number</b>	<b>Weekday and Date</b>	<b>Topics</b>	<b>Readings for Each Topic</b>
13	M 11/14	<b>HW4 DUE ONLINE BY 11:59 PM: Practice with IRT/IFA OPTIONAL REVISION TO HW3 DUE VIA ICON BY 11:59 PM</b>	
	T 11/15	Lecture 7, continued Example 7b: Longitudinal Measurement Invariance in CFA using Mplus	Edwards & Wirth (2009) Curran et al. (2014)
	R 11/17	Lecture 7, continued Example 7c: Multiple-Group Measurement Invariance in IFA using Mplus WLSMV Example 7d: Multiple-Group Measurement Invariance in IFA using Mplus ML	
14	M 11/21	<b>NO CLASS OR OFFICE HOURS THIS WEEK</b>	
	T 11/22	<b>NO CLASS OR OFFICE HOURS THIS WEEK</b>	
	R 11/24	<b>NO CLASS OR OFFICE HOURS THIS WEEK</b>	
15	M 11/28	<b>HW5 DUE VIA ICON BY 11:59 PM: IRT/IFA on Your Own Data</b>	
	T 11/29	Lecture 8: Higher-Order and Method Factor Models Example 8: Higher-Order CFA and IRT Models in Mplus	Brown (2015) ch. 8 Henninger & Meiser (2020 both) Chen et al. (2006) Reise et al. (in press)
	R 12/1	Lecture 8 and Example 8, continued	Bandalos (2021) Tay & Jebb (2018) Davidson et al. (2016) Zhang et al. (2022)
16	M 12/5	<b>FA5 DUE VIA ICON BY 11:59 PM</b>	
	T 12/6	Lecture 8, continued	
	R 12/8	Lecture 9: Structural Equation Modeling and Alternatives Example 9: Structural Equation Modeling in Mplus and R	Cole & Preacher (2014) Gonzalez et al. (in press) Curran et al. (2018) Sterba & Rights (in press) Yeng & Hancock (in press)
17	M 12/12	Office hours from 3:30-4:30 PM	
	T 12/13	NO CLASS, but office hours from 12:30-3:30 PM	
	W 12/14	Office hours from 3:30-4:30 PM	
	R 12/15	NO CLASS, but office hours from 12:30-3:30 PM	
	F 12/16	<b>HW6 DUE BY 5:00 PM ONLINE: (Practice with Invariance) OPTIONAL REVISION TO HW5 DUE VIA ICON BY 5:00 PM ALL OUTSTANDING WORK MUST BE COMPLETED BY 5:00 PM</b>	