Cognitive Diagnosis Modeling
16:300:696
Spring 2016
3 Credits
Monday, 7:40 – 10:30 PM
GSE Room 347

Instructor Name: Jimmy de la Torre	**Email address:** j.delatorre@rutgers.edu
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Office Hours: Monday, 6:30-7:30, or by appointment	**Prerequisites or other limitations:** Item Response Theory, or consent of the instructor
Mode of Instruction: ___ Lecture _X_ Seminar ___ Hybrid ___ Online ___ Other	**Permission required:** _X_ No __ Yes Directions about where to get permission numbers:

Learning Goals:

At the end of the course, students are expected to
1) be acquainted with the major approaches to diagnostic modeling;
2) understand the issues involved in constructing and analyzing cognitively diagnostic assessments; and
3) have a deep familiarity with the major areas of research in cognitive diagnosis modeling.

Course Catalog Description:

The course provides in-depth overview of cognitive diagnosis modeling, a novel psychometric framework for developing assessments and analyzing item-response data. In addition to the rationale, bases and frameworks for cognitive diagnosis modeling, the course covers some of the most recent developments in the area. These developments include models for cognitive diagnosis, model estimation and comparison, attribute and Q-matrix validation, computerized adaptive testing, and differential item functioning.

Class Materials/Textbooks:

There is no required textbook for this class. All reading assignments are based on selected articles and book chapters, and can be accessed from the course website.

Course Requirements and Grading Policy:

1) **Class Participation (30% of the Final Grade)**
Students are expected to actively contribute to the class discussion, and will be graded based on their participation. Comments and questions in the class discussion should be based on the assigned reading materials. In-class and homework exercises will also be discussed. Finally, students are also expected to participate in the class discussion by reporting on assigned topics.

2) **Project (40% of the Final Grade)**
An individual or two-person class project that illustrates the principles and applications of cognitive diagnosis modeling will be required. The project should be written up, and should be of conference or journal quality. In this project, students can choose to (1) do purely theoretical work, (2) develop and document his/her own computer code, (3) conduct a simulation study, or (4) analyze real data. The project is due on the last day (i.e., Week 16) of the class.

3) **Project Presentation (30% of the Final Grade)**
Week 15 will be devoted to project presentation. Each individual or group will be given at most 20 minutes to give a presentation based on their class project. The presentation will be graded based on its clarity, and the student's ability to respond to project-related questions.

The final letter grade will be assigned as follows:

Final Score	Letter Grade
90% and Above	A
80%-89%	B+
75%-79%	B
65%-74%	C+
60%-64%	C
Below 60%	F

Web Site: eCompanion (rutgersonline.net)

Class Schedule:

The class schedule below is subject to change if necessary.

Below are the topic/s to be covered each week and corresponding reading assignments. Different topics are separated by 1, 2, and so forth. Required readings are marked by †. Reading assignments must be completed prior to each meeting.

Week	Date	Topic/s	Reading Assignments
1	1/25	Introduction to Diagnostic Modeling Framework in Educational Assessment	†de la Torre, J. & Minchen. N. (2014) Mislevy, R., Almond, R., & Lukas, J. (2004) †NRC (2001) - Chapter 2
2	2/1	Defining and Validating Attributes	†Leighton, J. & Gierl. M. (2007) †NRC (2001) - Chapter 3 Pellegrino, J., Baxter, G., & Glaser, R. (1999)
3	2/8	Approaches to Diagnostic Modeling: Rule Space Methodology[1], Attribute Hierarchy Method[2], Bayesian Inference Network[3], Knowledge Space Theory[4], Nonparametric Approaches[5]	[3†]Almond, R., DiBello, L., Moulder, B., & Zapata-Rivera, J. (2007) [5†]Chiu, C.-Y., Douglas, J., & Li, X. (2009) [4†]Falmagne, J., Doignon, J., Koppen, M., Villano, M., & Johannesen, L. (1990) [1†]Gierl, M., Leighton, J., & Hunka, S. (2000) [2†]Leighton, J., Gierl, M., & Hunka, S. (2004)
4	2/15	IRT-based CDMs	†DiBello, L., & Stout, W. (2007) Haertel, E. (1989) Junker, B., & Sijtsma, K. (2001) †Rupp. A., & Templin, J. (2008)
5	2/22	CDM Estimation: Expectation-Maximization[1], Markov Chain Monte Carlo[2], and General Software Packages (Latent Gold[3] & Mplus[4])	[1†]de la Torre, J. (2009a) [2†]de la Torre, J., Douglas, J. (2004) [3]DeCarlo, L. (2011; Appendix A) [4]Rupp, A., Templin, J., & Henson, R. (2010; Chapter 9)
6	2/29	General CDMs[1] & Model Comparison[2]	[1†]de la Torre, J. (2011) [2]de la Torre, J., & Lee, Y.-S. (2013) [1] Henson, R., Templin, J., & Willse, J. (2009) [2†]Ma, W., Iaconangelo, C., & de la Torre, J. (2016) [1]von Davier, M. (2008)
7	3/7	Q-Matrix Validation	Chiu, C.-Y. (2013) †de la Torre, J. (2008) †de la Torre, J., & Chiu, C.-Y. (2015) Liu, J., Xu, G., & Ying, Z. (2012)

Week	Date	Topic/s	Reading Assignments
8	3/14	Spring Break	
9	3/21	GDINA R Package	†Ma, W., & de la Torre, J. (2016)
10	3/28	Model Fit Evaluation[1] & Person Fit Evaluation[2]	[1†]Chen, J., de la Torre, J., & Zhang, Z. (2013) [2]Cui, Y., & Li, J. (2015) [1]de la Torre, J., & Douglas, J. (2008) [1]Hansen, M., Cai, L., Monroe, S., & Li, Z. (2014) [2†]Liu, Y., Douglas, J., & Henson, R. (2009)
11	4/4	Attribute Estimation and Classification[1] & Differential Item Functioning[2]	[2†]Hou, L., de la Torre, J., & Nandakumar, R. (2014) [1†]Huebner, A., & Wang, C. (2011) [2]Li, X., & Wang, W. C. (2015) [1]Wang, W., Song, L., Chen, P., Meng, Y., & Ding, S. (2015)
12	4/11	AERA/NCME (No Class)	
13	4/18	CDM Applications to Proportional Reasoning[1], Psychiatric Data[2], & Situational Judgment Test[3]	[2†]de la Torre, J., van der Ark, L., & Rossi, G. (2015) [3†]Sorrel, M., Olea, J., Abad, F., de la Torre, J., Aguado, D., & Lievens, F. (in press) [1†]Tjoe, H., & de la Torre, J. (2014)
14	4/25	Optimal Test Design[1] & Computerized Adaptive Testing[2]	[2]Cheng, Y. (2009) [1]Finkelman, M., Kim, W., & Roussos, L.(2009) [1]Henson, R., & Douglas, J. (2005) [†]Kaplan, M., de la Torre, J., & Barrada, J. (2015) [1†]Kuo, B.-C., Pai, H.-S., & de la Torre, J. (under review) [2]Wang, C. (2013) [2]Wang, C., Chang, H., & Douglas, J. (2011) [2]Wang, C., Chang, H., & Huebner, A. (2011)

Week	Date	Topic/s	Reading Assignments
15	5/2	Project Presentation	
16	5/9	Project Submission (Due at 7:40 PM)	
		CDMs for Multiple Choice[1], Polytomous Attributes[2], Polytomous Response[3], & Continuous Response[4]	[2]Chen, J., & de la Torre, J. (2013) [1]de la Torre, J. (2009b) [3†]Ma, W., & de la Torre, J. (under review) [4†]Minchen, N., de la Torre, J., & Liu, Y. (under review) [2,3]von Davier, M. (2008)

Academic Integrity Policy:

The Office of Student Conduct supervises issues related to violations of academic integrity (see http://academicintegrity.rutgers.edu). Please familiarize yourself with the university policy on academic integrity at http://academicintegrity.rutgers.edu/files/documents/AI_Policy_2013.pdf

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COMPLETE REFERENCES

1. Almond, R., DiBello, L., Moulder, B., & Zapata-Rivera, J. (2007). Modeling diagnostic assessments with Bayesian networks. *Journal of Educational Measurement, 44,* 341–359.

2. Chen, J., & de la Torre, J. (2013). A general cognitive diagnosis model for expert-defined polytomous attributes. *Applied Psychological Measurement, 37,* 419-437.

3. Chen, J., de la Torre, J., & Zhang, Z. (2013). Relative and absolute fit evaluation in cognitive diagnosis modeling. *Journal of Educational Measurement, 50,* 123-140

4. Cheng, Y. (2009). When cognitive diagnosis meet computerized adaptive testing: CD-CAT. *Psychometrika, 74*, 619-632.

5. Chiu, C.-Y. (2013). Statistical Refinement of the Q-Matrix in Cognitive Diagnosis. *Applied Psychological Measurement, 37*, 598–618.

6. Chiu, C.-Y., Douglas, J., & Li, X. (2009). Cluster analysis for cognitive diagnosis: Theory and applications. *Psychometrika, 74*, 633–665.

7. Cui, Y., & Li, J. (2015). Evaluating person fit for cognitive diagnostic assessment. *Applied Psychological Measurement, 39*, 223-238.

8. de la Torre, J. (2008). An empirically-based method of Q-matrix validation for the DINA model: Development and applications. *Journal of Educational Measurement, 45*, 343-362.

9. de la Torre, J. (2009a). DINA model and parameter estimation: A didactic. *Journal of Educational and Behavioral Statistics, 34*,115-130.

10. de la Torre, J. (2009b). A cognitive diagnosis model for cognitively-based multiple-choice options. *Applied Psychological Measurement, 33*, 163-183.

11. de la Torre, J. (2011). The generalized DINA model framework. *Psychometrika, 76*, 179-199.

12. de la Torre, J., & Chiu, C.-Y. (2015). A general method of empirical Q-matrix validation. *Psychometrika*. DOI: 10.1007/s11336-015-9467-8

13. de la Torre, J., & Douglas, J. (2004). Higher-order latent trait models for cognitive diagnosis. *Psychometrika, 69,* 333-353.

14. de la Torre, J., & Douglas, J. (2008). Model evaluation and selection in cognitive diagnosis: An analysis of fraction subtraction data. *Psychometrika, 73,* 595-624.

15. de la Torre, J., & Minchen, N. (2014). Cognitively diagnostic assessments and the cognitive diagnosis model framework. *Psicología Educativa, 20,* 89-97.

16. de la Torre, J., & Lee, Y.-S. (2013). Evaluating the Wald test for item-level comparison of saturated and reduced models in cognitive diagnosis. *Journal of Educational Measurement, 50,* 355-373.

17. de la Torre, J., van der Ark, L., & Rossi, G. (2015). Analysis of clinical data from a cognitive diagnosis modeling framework. *Measurement and Evaluation in Counseling and Development*. DOI: 10.1177/0748175615569110

18. DeCarlo, L. (2011). On the analysis of fraction subtraction data: The DINA model, classification, latent class sizes, and the Q-matrix. *Applied Psychological Measurement, 35*, 8-26.

19. DiBello, L., & Stout, W. (2007). IRT-cased cognitive diagnostic models and related methods. *Journal of Educational Measurement, 44*, 285–291.

20. Falmagne, J., Doignon, J., Koppen, M., Villano, M., & Johannesen, L. (1990). Introduction to knowledge spaces: How to build, test, and search them. *Psychological Review, 97*, 201-224.

21. Finkelman, M., Kim, W., & Roussos, L. A. (2009). Automated test assembly for cognitive diagnosis models using a genetic algorithm. *Journal of educational measurement*, 46(3), 273-292.

22. Gierl, M., Leighton, J., & Hunka, S. (2000). Exploring the logic of Tatsuoka's rule-space model for test development and analysis. *Educational Measurement: Issues and Practice, 19*, 34-44.

23. Hansen, M., Cai, L., Monroe, S., & Li, Z. (2014). *Limited-information goodness-of-fit testing of diagnostic classification item response theory models*. CRESST report 840. Retrieved from https://www.cse.ucla.edu/products/reports/R840.pdf

24. Haertel, E. (1989). Using restricted latent class models to map the skill structure of achievement items. *Journal of Educational Measurement, 26*, 333-352.

25. Henson, R., & Douglas, J. (2005). Test construction for cognitive diagnosis. *Applied Psychological Measurement, 29*, 262-277.

26. Henson, R., Templin, J., & Willse, J. (2009). Defining a family of cognitive diagnosis models using log-linear models with latent variables. *Psychometrika, 74*, 191–210.

27. Hou, L., de la Torre, J., & Nandakumar, R. (2014). Differential item functioning assessment in cognitive diagnostic modeling: Application of the Wald test to investigate DIF in the DINA model. *Journal of Educational Measurement, 51*, 98-125.

28. Huebner, A., & Wang, C. (2011). A note on comparing examinee classification methods for cognitive diagnosis models. *Educational and Psychological Measurement, 71*, 407-419.

29. Junker, B., & Sijtsma, K. (2001). Cognitive assessment models with few assumptions, and connections with nonparametric item response theory. *Applied Psychological Measurement, 25,* 258–272.

30. Kaplan, M., de la Torre, J., & Barrada, J. (2015). New Item Selection Methods for Cognitive Diagnosis Computerized Adaptive Testing. *Applied Psychological Measurement, 39,* 167-188.

31. Kuo, B.-C., Pai, H.-S., & de la Torre, J. (under review). Modified cognitive diagnostic index and modified attribute-level discrimination index for test construction.

32. Leighton, J., & Gierl, M. (2007). Defining and evaluating models of cognition used in educational measurement to make inferences about examinees' thinking processes. *Educational Measurement: Issues and Practice, 26,* 3-16.

33. Leighton, J., Gierl, M., & Hunka, S. (2004). The attribute hierarchy method for cognitive assessment: A variation on Tatsuoka's rule-space approach. *Journal of Educational Measurement, 41,* 205-237.

34. Li, X., & Wang, W.-C. (2015). Assessment of differential item functioning under cognitive diagnosis models: The DINA model example. *Journal of Educational Measurement, 52,* 28-54.

35. Liu, J., Xu, G., & Ying, Z. (2012). Data-driven learning of Q-matrix. *Applied Psychological Measurement. 36,* 609-618.

36. Liu, Y., Douglas, J., & Henson, R. (2009). Testing person fit in cognitive diagnosis. *Applied Psychological Measurement. 33,* 579-598

37. Ma, W., & de la Torre, J. (2016). *GDINA: The Generalized DINA model framework, R package.*

38. Ma, W., & de la Torre, J. (under review). A sequential cognitive diagnosis model for polytomous responses.

39. Ma, W., Iaconangelo, C., & de la Torre, J. (2016). Model similarity, model selection and attribute classification. *Applied Psychological Measurement.* DOI: 10.1177/0146621615621717

40. Minchen, N., de la Torre, J., & Liu, Y. (under review). *A cognitive diagnosis model for continuous response.*

41. Mislevy, R., Almond, R., Lukas, J. (2004). *A brief introduction to Evidence-Centered Design.* CSE Technical Report 632, The National Center for Research on Evaluation,

Standards, and Student Testing (CRESST), Center for the Study of Evaluation (CSE), UCLA, Los Angeles, CA.

42. National Research Council (2001). *Knowing what students know: The science and design of educational assessment*. Committee on the Foundations of Assessment. In J. Pellegrino, N. Chudowsky, & R. Glaser (Eds.), *Board on Testing and Assessment, Center for Education*. Washington, DC: National Academy Press.

43. Pellegrino, J., Baxter, G., & Glaser, R. (1999). Addressing the "two disciplines" problem: Linking theories of cognition and learning with assessment and instructional practices. In A. Iran-Nejad & P. Pearson (Eds.), *Review of Research in Education* (pp. 307-353). Washington, DC: American Educational Research Association.

44. Rupp. A., & Templin, J. (2008). Unique characteristics of diagnostic classification models: A comprehensive review of the current state-of-the-art. *Measurement, 6*, 219-262.

45. Rupp, A., Templin, J., & Henson, R. (2010*). Diagnostic measurement: Theory, methods, and applications*. New York: Guilford Press.

46. Sorrel, M., Olea, J., Abad, F., de la Torre, J., Aguado, D., & Lievens, F. (in press). Validity and reliability of situational judgement test scores: A new approach based on cognitive diagnosis models. *Organizational Research Methods*.

47. Tjoe, H., & de la Torre, J. (2014). The identification and validation process of proportional reasoning attributes: An application of a cognitive diagnosis modeling framework. *Mathematics Education Research Journal, 26*, 237-255.

48. Wang, C. (2013). Mutual information item selection method in cognitive diagnostic computerized adaptive testing with short test length. *Educational and Psychological Measurement, 73*, 1017-1035.

49. Wang, C., Chang, H., & Huebner, A. (2011). Restrictive stochastic item selection methods in cognitive diagnostic CAT. *Journal of Educational Measurement, 48,* 255-273.

50. Wang, C., Chang, H., & Douglas, J. (2011). Combining CAT with cognitive diagnosis: A weighted item selection approach. *Behavior Research Methods, 44*, 95-109.

51. Wang, W., Song, L., Chen, P., Meng, Y., & Ding, S. (2015). Attribute-level and pattern-level classification consistency and accuracy indices for cognitive diagnostic assessment. *Journal of Educational Measurement, 52*, 457-476.

52. von Davier, M. (2008). A general diagnostic model applied to language testing data. *British Journal of Mathematical and Statistical Psychology, 61*, 287–307.