Cross-National Exploration of Secondary Math Teacher Preparation: Descriptive Discriminant Analysis Insights and Tableau Visualizations

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Center for the Science of Information | Virtual Brown Bag Research Discussion

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Today's Presenters

Genéa Stewart

- Project Coordinator
- 2nd year Ph.D. Student in UNT's Department of Educational Psychology (Research, Measurement & Statistics)

Cary Jim

- Lead Data Visualizer
- 3rd year Ph.D. Student at UNT's Department of Information Science, concentrate in Data Science
- Minor: Research, Measurement & Statistics

Milushka Elbulok-Charcape

- Qualitative Data Insights
- Research interests include research literacy and academic identity in STEM
- PhD Candidate, Graduate Center CUNY

Dinuka Gallaba

- Data Preparation
- Research interests include physics and metal organic frameworks
- PhD Candidate, Southern Illinois University

Background: U.S. Student Achievement

2015 TIMSS RESULTS (8TH GRADE)

EDUCATION SYSTEM	Mean	10th Percentile	90th Percentile
Canada	527	434	613
Chile	427	323	531
Chinese Taipei-China	599	459	714
United Kingdom-England	498	414	624
Hong Kong-China	594	489	686
Japan	586	470	699
Republic of Korea	606	491	711
Lebanon	442	345	539
Lithuania	511	409	608
Russian Federation	538	429	641
Singapore	621	505	715
Sweden	501	406	590
Turkey	458	324	599
United States	518	408	624
Average	**493**	**364**	**613**

SOURCE: National Center for Education Statistics, International Association for the Evaluation of Educational Achievement

2015 PISA RESULTS (15 YEAR OLDS)

EDUCATION SYSTEM	Mean	10th Percentile	90th Percentile
Canada	516	400	627
Chile	423	313	534
Chinese Taipei-China	542	404	670
United Kingdom	493	371	610
Hong Kong-China	548	426	659
Japan	532	416	643
Republic of Korea	524	391	649
Lebanon	396	268	531
Lithuania	478	365	590
Russia	494	387	601
Singapore	564	436	682
Sweden	494	376	609
Turkey	420	317	529
United States	470	355	585
Average	490	373 ○	605 ○

○ Percentile cut score is higher than U.S. percentile cut score at the .05 level of statistical significance. ○ Percentile cut score is lower than U.S. percentile cut score at the .05 level of statistical significance.

Sources: National Center for Education Statistics, Organization for Economic Cooperation and Development

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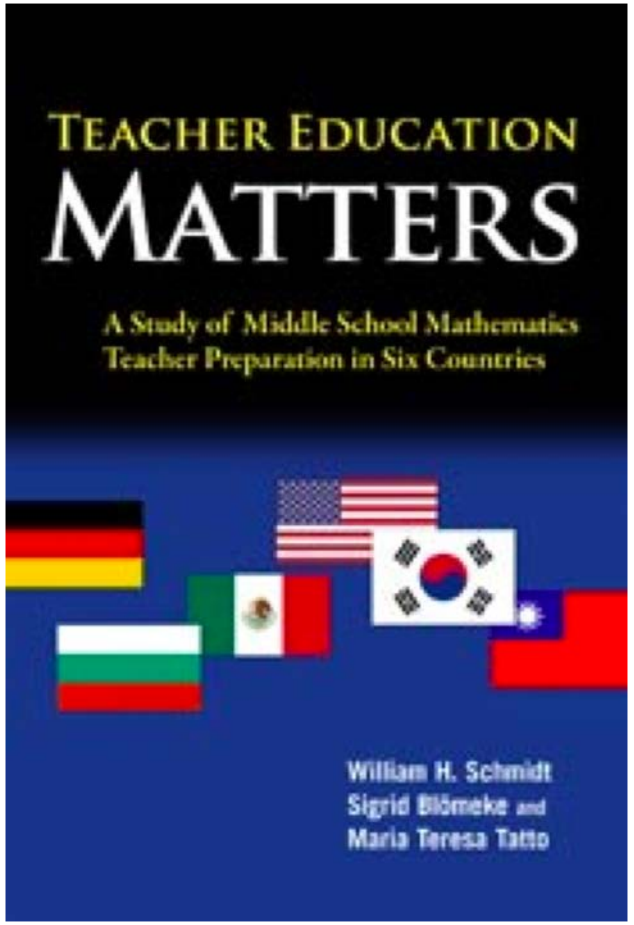
MT21 Study

- Math Teaching in the 21st Century is an NSF funded project
- Dataset obtained through the Inter-university Consortium for Political and Social Research (ICPSR) repository
- Conceived as a follow-up to the 1995 Trends in International Math and Science Study (TIMSS)
- Compared how middle school math teachers are prepared in 6 different countries
- *Principle areas of focus*:
  - Beliefs and perspectives on teaching and learning
  - Academic program learning opportunities
  - Content knowledge



Authors:

William H. Schmidt, Maria Teresa Tatto, Kiril Bankov, Sigrid Blömeke,Tenoch Cedillo, Leland Cogan, Shin Il Han, Richard Houang, Feng Jui Hsieh, Lynn Paine, Marcella Santillan and John Schwille.

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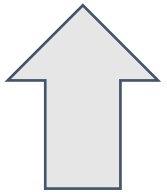
Descriptive Discriminant Analysis

Overview:

- Describe group differences on a "set" of response variables, simultaneously
  - Minimize Type I error
- Identify characteristics or constructs that discriminate among groups (*How many? Which ones?*)
- Can be used as a post-hoc to a MANOVA, or as a stand-alone procedure
- A linear combination (function) produces the synthetic outcome variable; multivariate group means on the synthetic variable are called "centroids"

(Huberty et al., 2006)

$$D_{zi} = d_{i1}z_1 + d_{i2}z_2 + \cdots + d_{ip}z_p$$



In the current study, a future teacher's standardized score on the *i*th discriminant function (D*i*) is found by multiplying the standardized score on each predictor (z) by its standardized discriminant function coefficient (d*i)* and then adding the products for all predictors.

(Tabachnick & Fidell, 2019)

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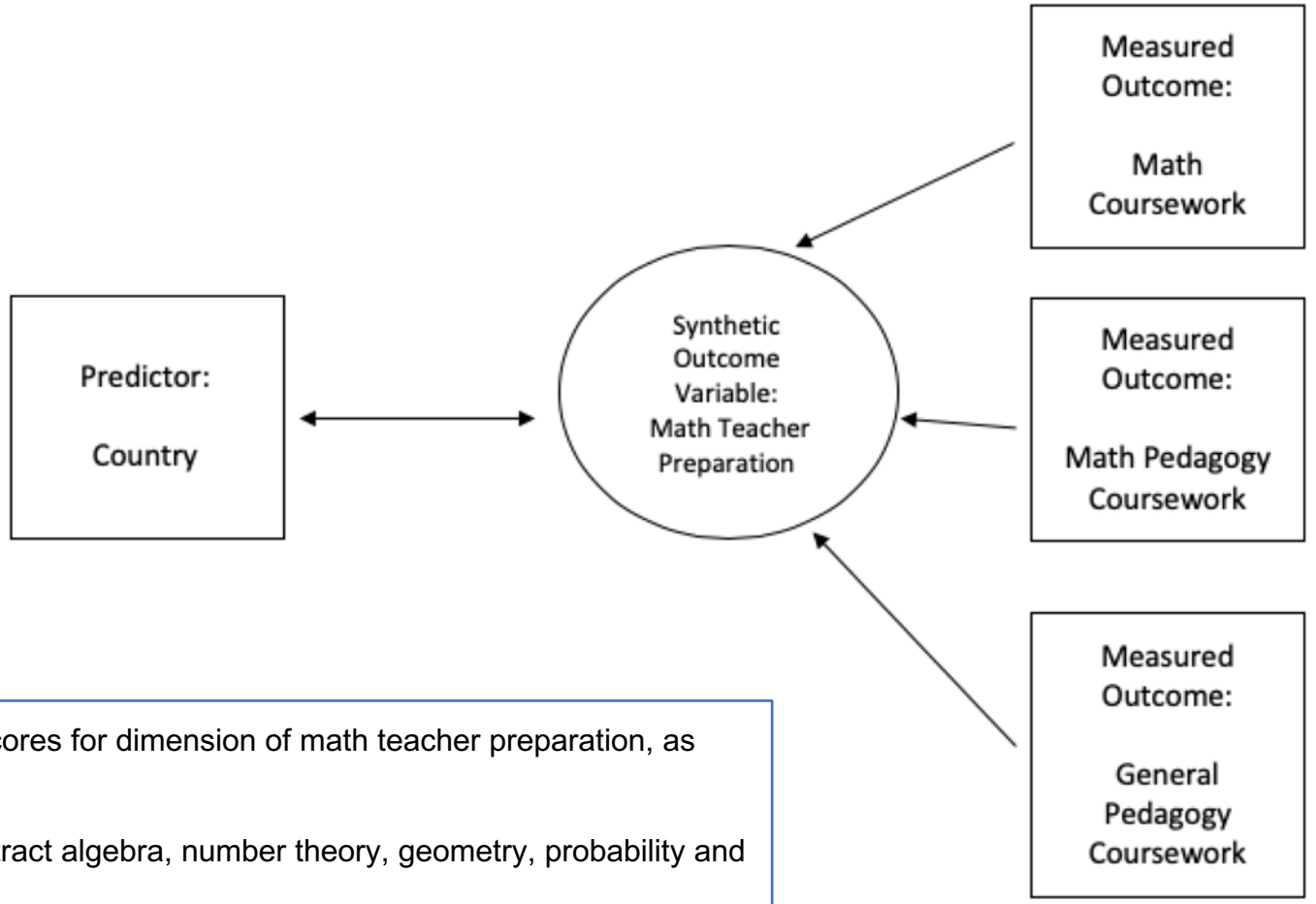
Descriptive Discriminant Analysis: Research Questions

Our Research Questions:

1. Are there mean differences among the six countries in some composite outcome (discriminant function)?
2. If so, where are the differences coming from?
   a. What does the synthetic outcome represent?



Note. Composite Outcome Variables were computed as sum scores for dimension of math teacher preparation, as hypothesized.

Math Coursework: history of mathematics, linear algebra, abstract algebra, number theory, geometry, probability and statistics, multivariate calculus, and differential equations
Math Pedagogy Coursework: general mathematics pedagogy, methods of solving school mathematics problems, psychology of mathematics, mathematics curricula in schools, and teaching practices in mathematics.
General Pedagogy Coursework: theory of instruction, lesson planning, classroom management, and history, philosophy and sociology of education

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Descriptive Discriminant Analysis Results (1/4)

Our Research Questions:

1. Is there a difference among the six countries in some composite outcome?
2. If so, where is it coming from?

Tests of Statistical Significance

Function	*Wilks's Lambda*	χ^2	*df*	*p*
1-3	.511	1759.297	15	< .001
2-3	.815	536.614	8	< .001
3	.932	185.819	3	< .001

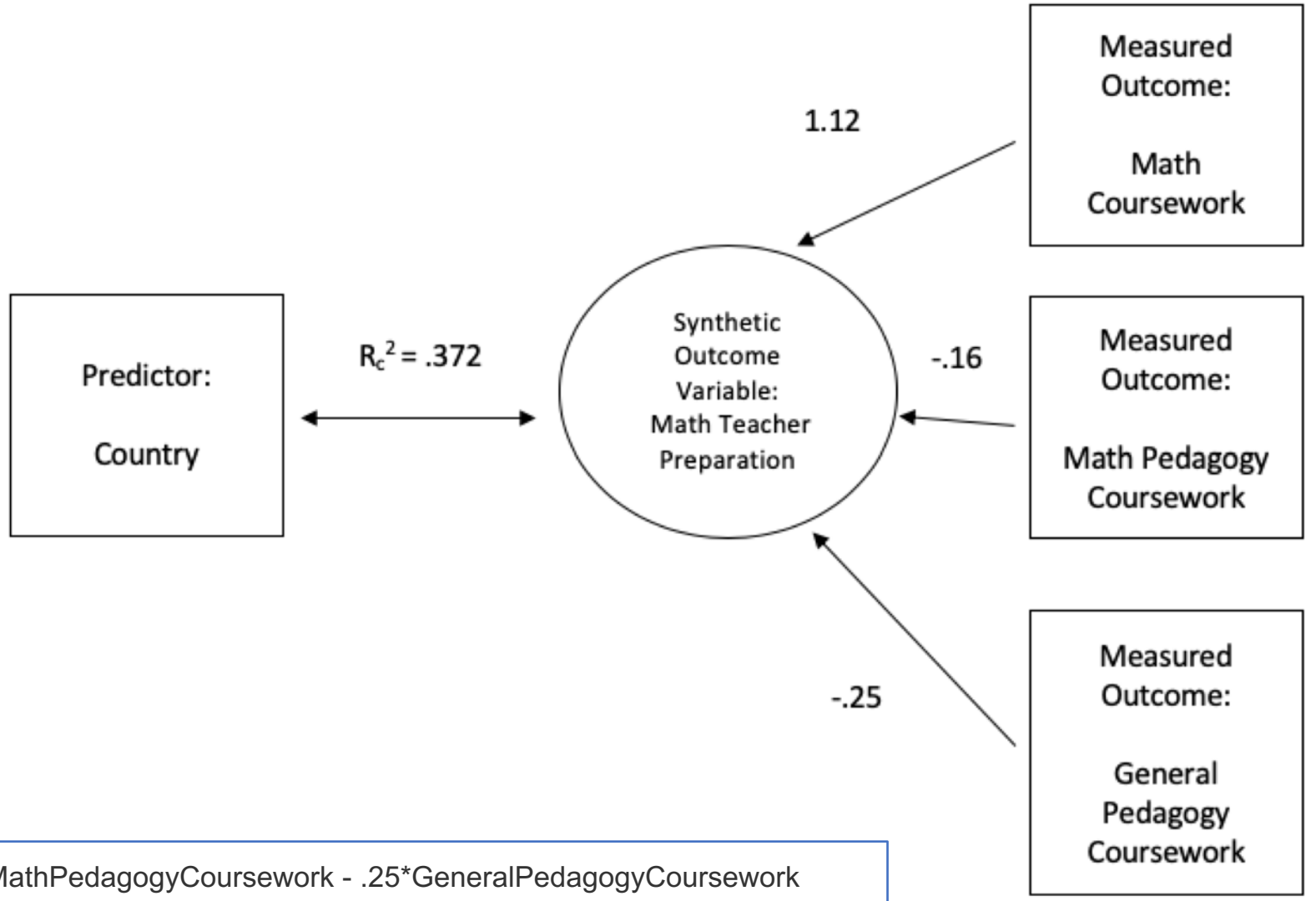
Canonical Correlations for Each Function

Function	*Eigenvalue*	R_c	R_c^2
1	.594	0.61	.372
2	.143	0.354	.125
3	.073	0.262	.069

Standardized Discriminant Function and Structure Coefficients for the Six Countries

Scale	*Coefficient*	r_s	r_s^2
Function 1			
Math Coursework	1.123	.948*	.899
Math Pedagogy	-.156	.23	.053
General Pedagogy	-.252	.114	.013

Descriptive Discriminant Analysis Results (2/4)



D = 1.12*MathCoursework -.16*MathPedagogyCoursework - .25*GeneralPedagogyCoursework

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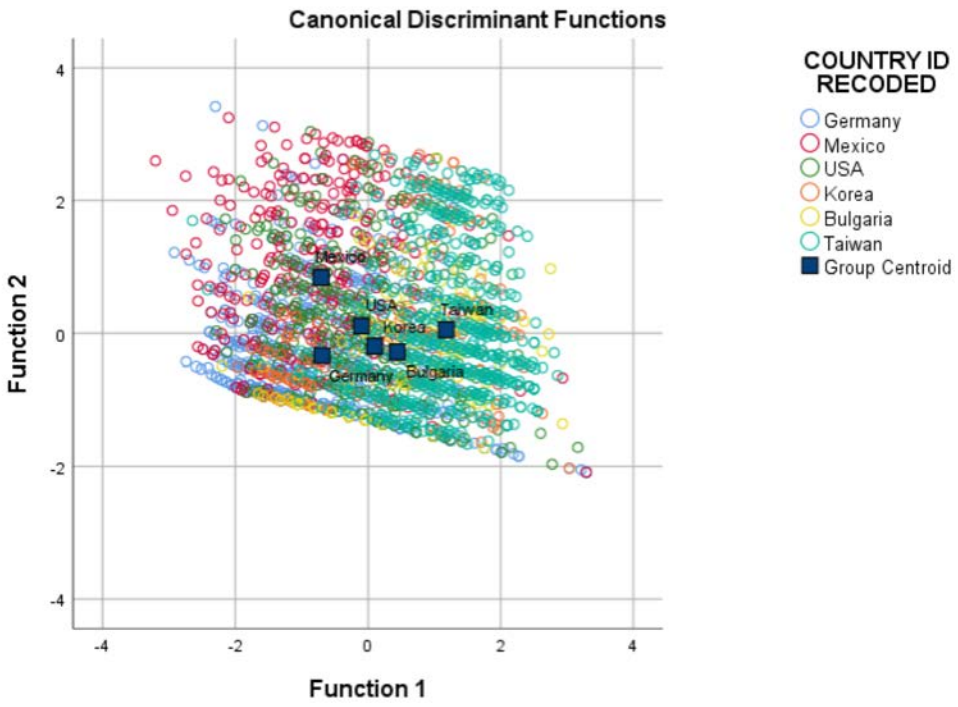
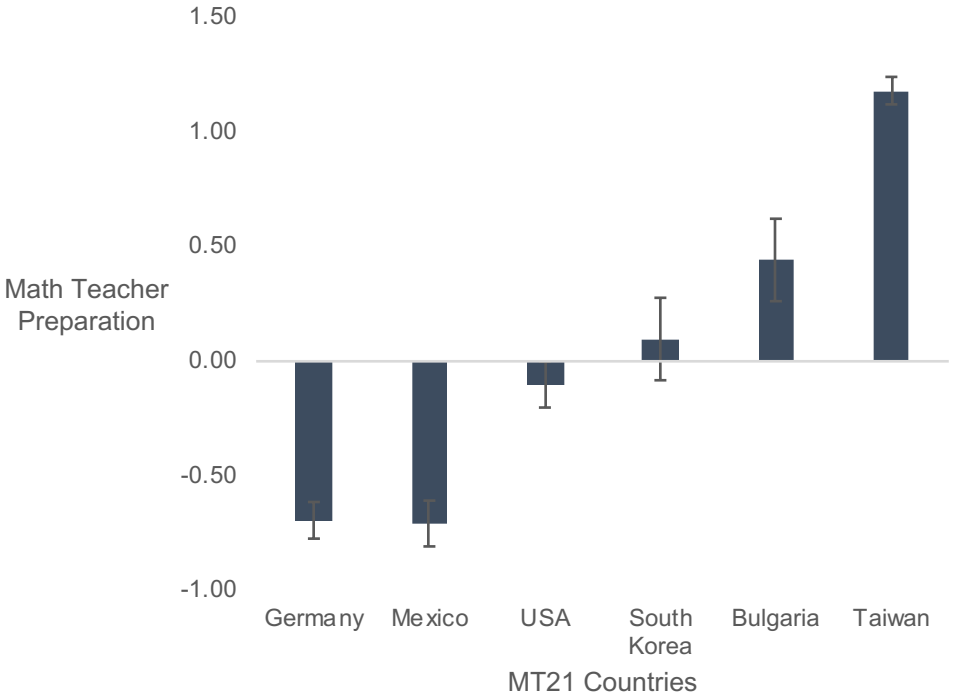
Descriptive Discriminant Analysis Results (3/4)





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Descriptive Discriminant Analysis Results (4/4)

Absolute Cohen's d Effect Sizes of Differences in Math Teacher Preparation for Function 1

	1	2	3	4	5	6
1. Germany						
2. Mexico	0.02					
3. USA	*0.58*	*0.62*				
4. South Korea	*0.66*	*0.7*	0.17			
5. Bulgaria	**1.06**	**1.12**	*0.52*	0.28		
6. Taiwan	**2.01**	**2.12**	**1.43**	**0.99**	**0.78**	

Note. Italicized numbers represent a moderate magnitude of effect, whereas numbers in bold represent a large magnitude of effect.

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Descriptive Discriminant Analysis: Some Implications & Limitations

- Recent research that suggests statistically significant relationships between rigorous math teacher coursework and self-reported preparation to teach math (Schmidt et al., 2017)
  - Our findings suggest that U.S. teachers may not be prepared enough to be internationally competitive.
- Variation in representativeness of samples across countries (e.g. # of institutions, # of teachers, diversity of samples)
- Time frame of research
- Linked student data on international assessments such as PISA or TIMSS was not provided, thus no direct correlations to student achievement can be assessed

Let’s take a closer look at these differences…

Are cross-national studies comparing apples to apples, or apples to oranges?

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Qualitative insights from around the globe…

Meet the middle school math teachers in your case study

Nedjalka Mimitrova – Bulgaria

Lukas Becker – Germany

Javier Lopez – Mexico

Eun-Young Choe – South Korea

Fong Wang – Taiwan

Judy Brazil – USA

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	Additional Duties	Salaries	Employment/Job Opportunities	High School Entrance	Resources
 Bulgaria	Administrative, Organizational	$	Job security	National Exams	Limited
 Germany	Administrative Sports	$$ (variable)	Difficult to secure a position	3 tracks	Variable
 Mexico	Administrative	$ (variable)	Difficult to secure a position	½ don't attend after 9th grade	Variable
 South Korea	Cleaning, Student Discipline and Hygiene	$$	Government ensures positions are available	Lottery system	Average
 Taiwan	Administrative, Student Discipline	$$$	Competitive	National exams	Above average
 United States	Administrative, Organizational	$ (variable)	Shortage of teachers (math/science)	Grades, recommendations, exams	Variable

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Data Viz for Education Practitioners

- Explanatory Analysis and Communication
- Potential Users of the Work and the Message
- Storytelling (Knaflic, 2015; Kosara & Mackinlay, 2013)
- Interactive dashboard in a collaborative settings with live presentation

Consideration of the Data

- Continuous data
- Scales of each domain varies
- Multilevel analysis (The role of OPL in Teacher Preparation)
    - **Opportunity to Learn (OPL)** vs **domains** and **country levels**

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1	**Mathematics Content Knowledge (Math Coursework)**	Algebra
		Function
		Number
		Geometry
		Data
	Mathematics Pedagogy Knowledge	Curriculum
		Teaching
		Students
2	**General Pedagogical Knowledge**	General Pedagogy
3	**General Professional Beliefs**	Algorithmic
		Usefulness
		Math Skills
		Math Reasoning

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4	**Beliefs Related to Classroom Practices**	Ignore
		Ask Other Student
		Teacher Addresses
	Classroom Management Beliefs	Warn of Consequences
		Motivational Instructional Activity
		Establishing Rules
5	**Approaches to Teaching Mathematics**	More Constructivist Approach
		Traditional Approach
	Use of Student Work Groups	Academic Reasons
		Individual Differences
		Managing Teaching

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Link to MT21 Public Dashboards

http://tiny.cc/MT21VIZ

Modern Modeling Methods
2020 Conference | 9th Annual Meeting | Poster Proposal

Type of Submission: Poster

Title: Using Markov Chain Monte Carlo Methods and Bayesian Estimation to Investigate Cross-National Teacher Preparedness and Professional Practices

Abstract:

Oftentimes, social science and policy researchers wish to examine how various macro-level country factors relate to differences in outcomes. However, many secondary datasets only offer small cluster sample sizes for multi-country data which severely restricts researchers' ability to estimate multi-level effects on outcomes and draw any robust conclusions. Bryan and Jenkins (2013) recommended the use of Bayesian estimation methods for more reliable estimations when the country level sample size is smaller than traditionally recommended 30. Using cross-national data from the 2018 International Questionnaire of the Teaching and Learning International Survey (TALIS), we will investigate model fitting of variance components for teachers' preparation, instructional practices, and beliefs across 15 countries. We will demonstrate this method using the Bayesian Regression Models (brms) package in R. This project is supported by Purdue University's Information Frontiers Learning Program at the Center for the Science of Information, a National Science Foundation Center.

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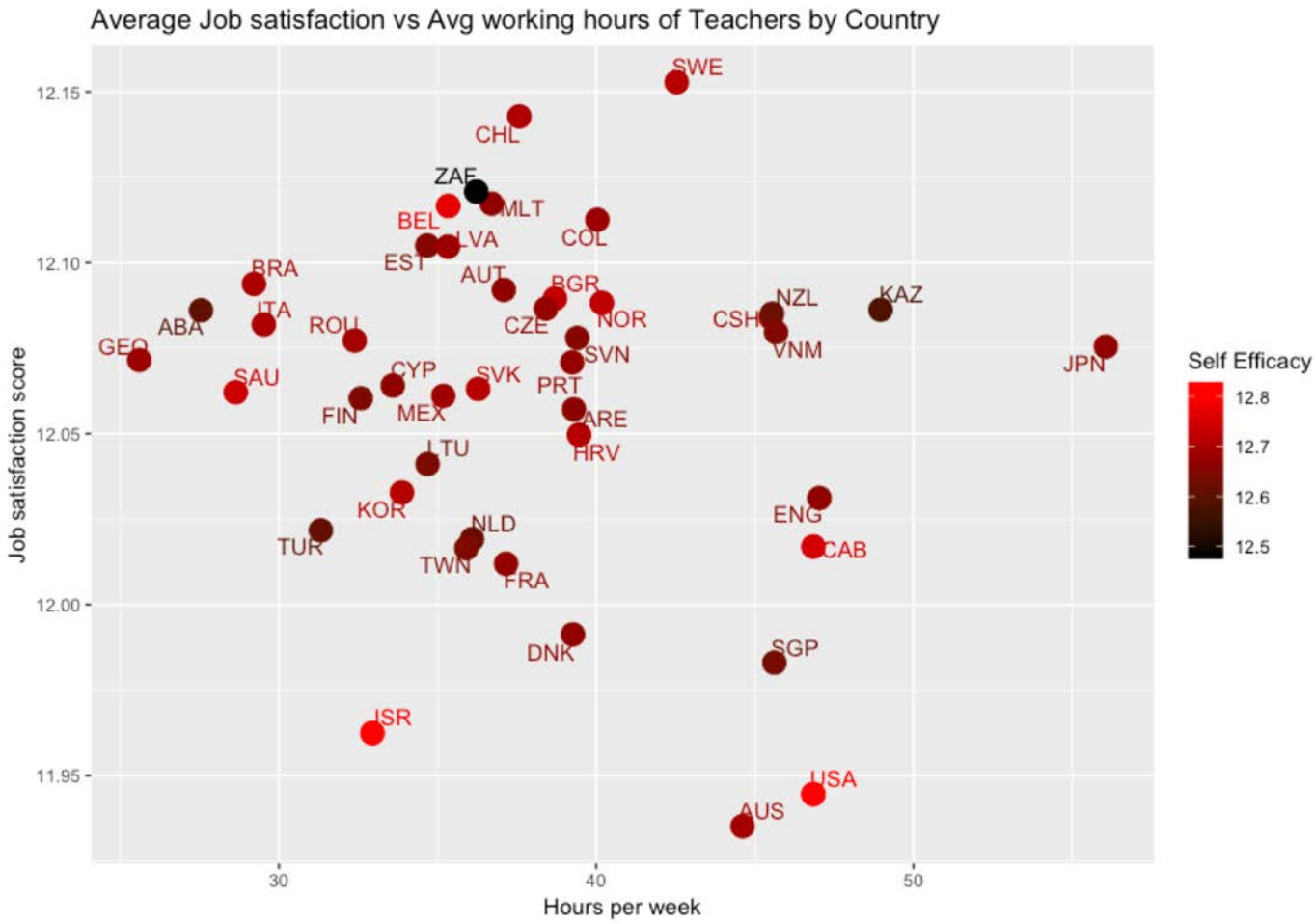
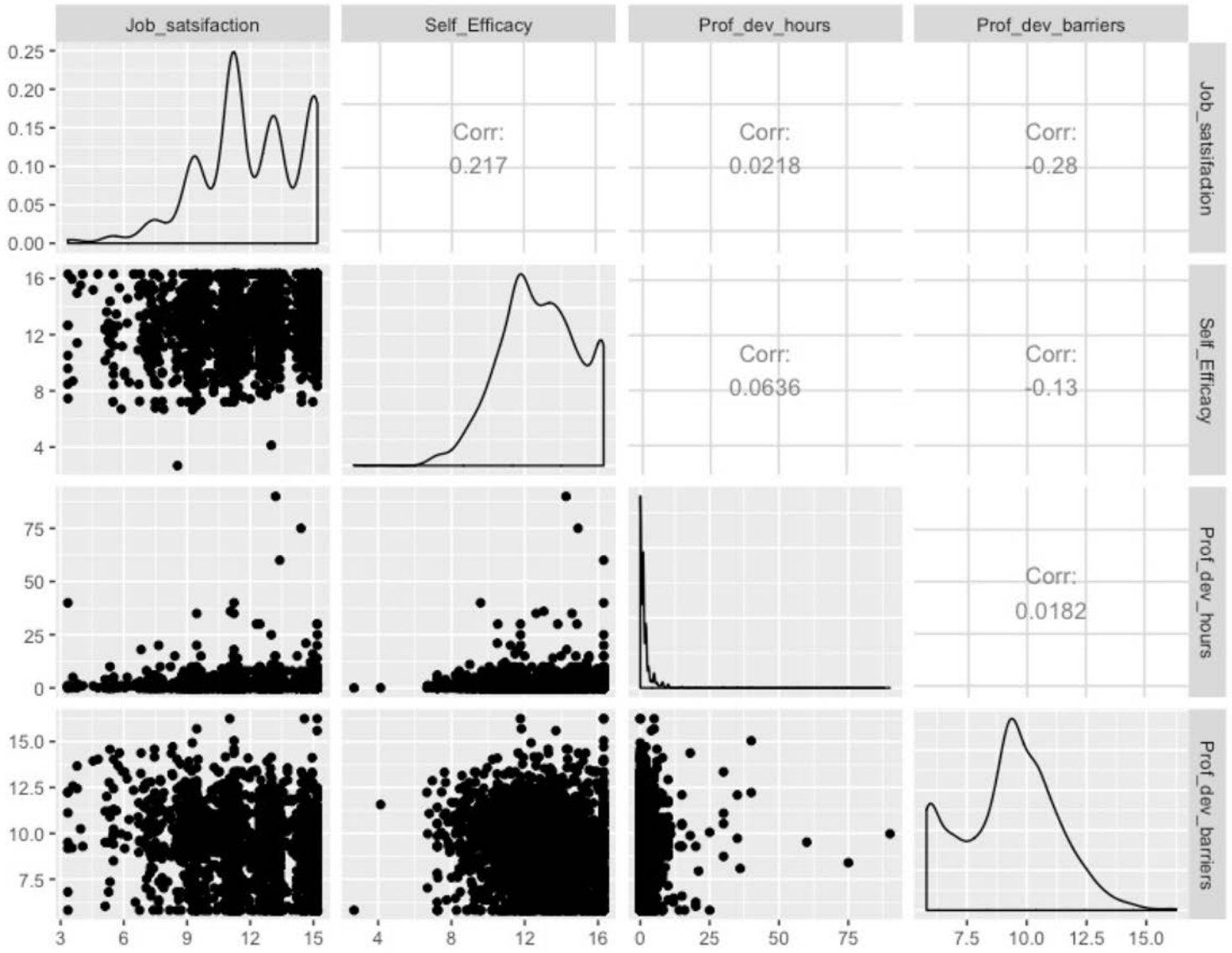
Master Data Set : OECD Teaching and Learning International Survey (TALIS) 2018

Subset : Lower secondary school level

- Primarily focused on the learning environment,professional development and working conditions of teachers in schools.
- Conducted over **49** Countries in **two levels.** (Individual teachers and Schools/centers).
- A standardized method of sampling, and survey distribution were strictly followed.



TALIS 2018 USA Lower secondary school level

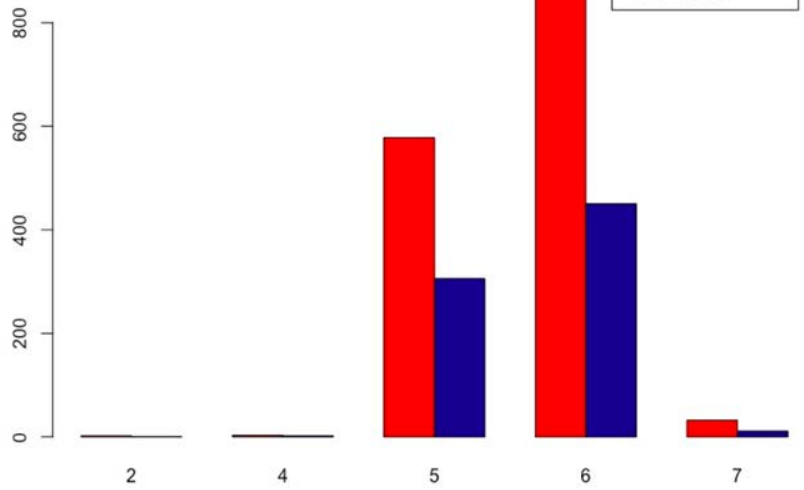


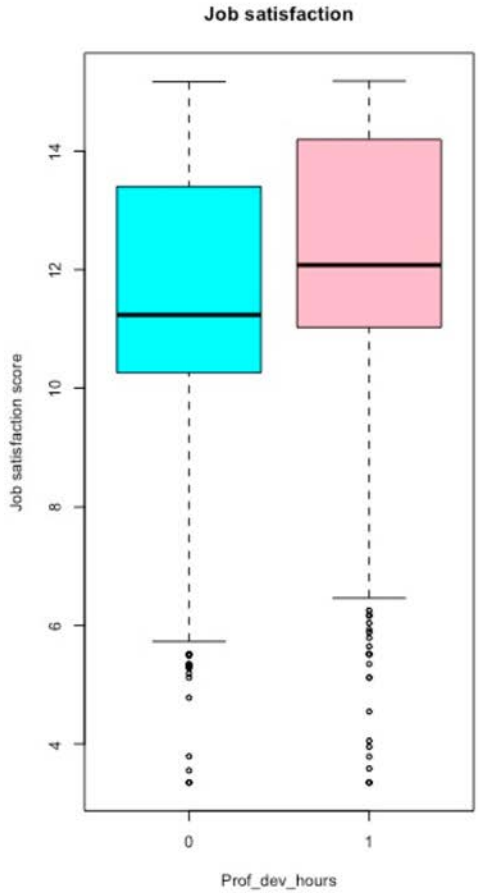
Many of the specific parameters such as teachers' attitudes and self-efficacy, cannot be measured directly, but only through survey questions designed to expressed opinions.

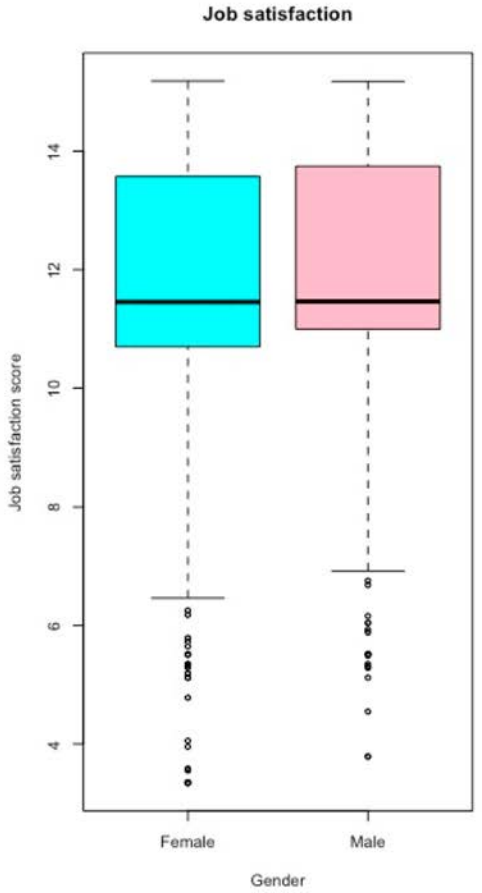
The TALIS 2018 provides its users with a scaling procedure for parameters like job satisfactions, self efficacy which can be analysed with parametric statistical techniques

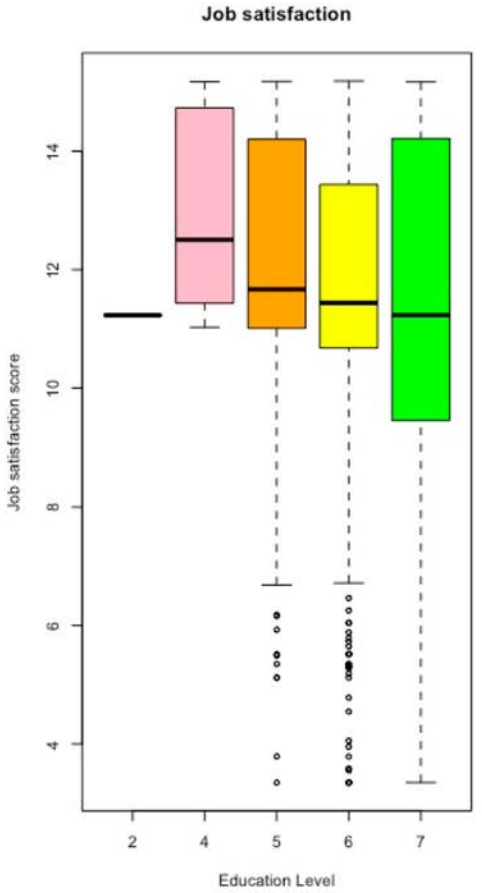
TALIS 2018 USA Lower secondary school level .. cont

Composition of the data set









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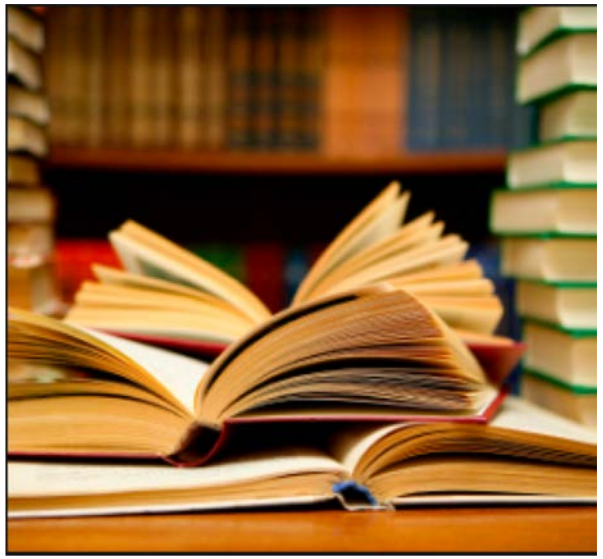

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Additional Resources

National Center for Educational Statistics, International Data Explorer: https://nces.ed.gov/surveys/international/ide/

Tableau Training:

https://www.tableau.com/learn/training/20194

Podcast, The State of American Education: https://the1a.org/shows/2019-12-17/the-state-of-american-education

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Thank you to our supporters!

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