The Invariance of the easyCBM® Mathematics Measures Across Educational Setting, Language, and Ethnic Groups

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easyCBM®

- Online benchmark and progress monitoring tool

- Designed for use within a response to intervention framework

- Adhered to principles of Universal Design for Assessment during development

- Available in Reading and Math
  - 20 alternate forms in Reading
  - 13 alternate forms in Math
    - Forms constructed to be of equivalent difficulty with a 1PL Rasch IRT model

easyCBM® Adoption

Total number of users

– 53,802 registered users nationwide

– 427,609 students

– 1,727,018 tests taken

New registrations for free site

– 100+ in a day

– 1,034 in last 7 days

– 4,141 in last 30 days

Universal Design for Assessment

- Process aimed at maximizing the opportunity for students to demonstrate ability on the tested constructs.

- Takes into account diverse test taking population

Principles include

Measure true constructs while eliminating irrelevant ones	Ability to change formatting without compromising the validity of results
Clear format and visual information	Being concise and clear in language

Example Item
first grade – number and operations

□○○△□○○_□

What goes here?

- ○ □
- ○ ○
- ○ △

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Read-aloud option available in grades K-1

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NCTM Focal Points

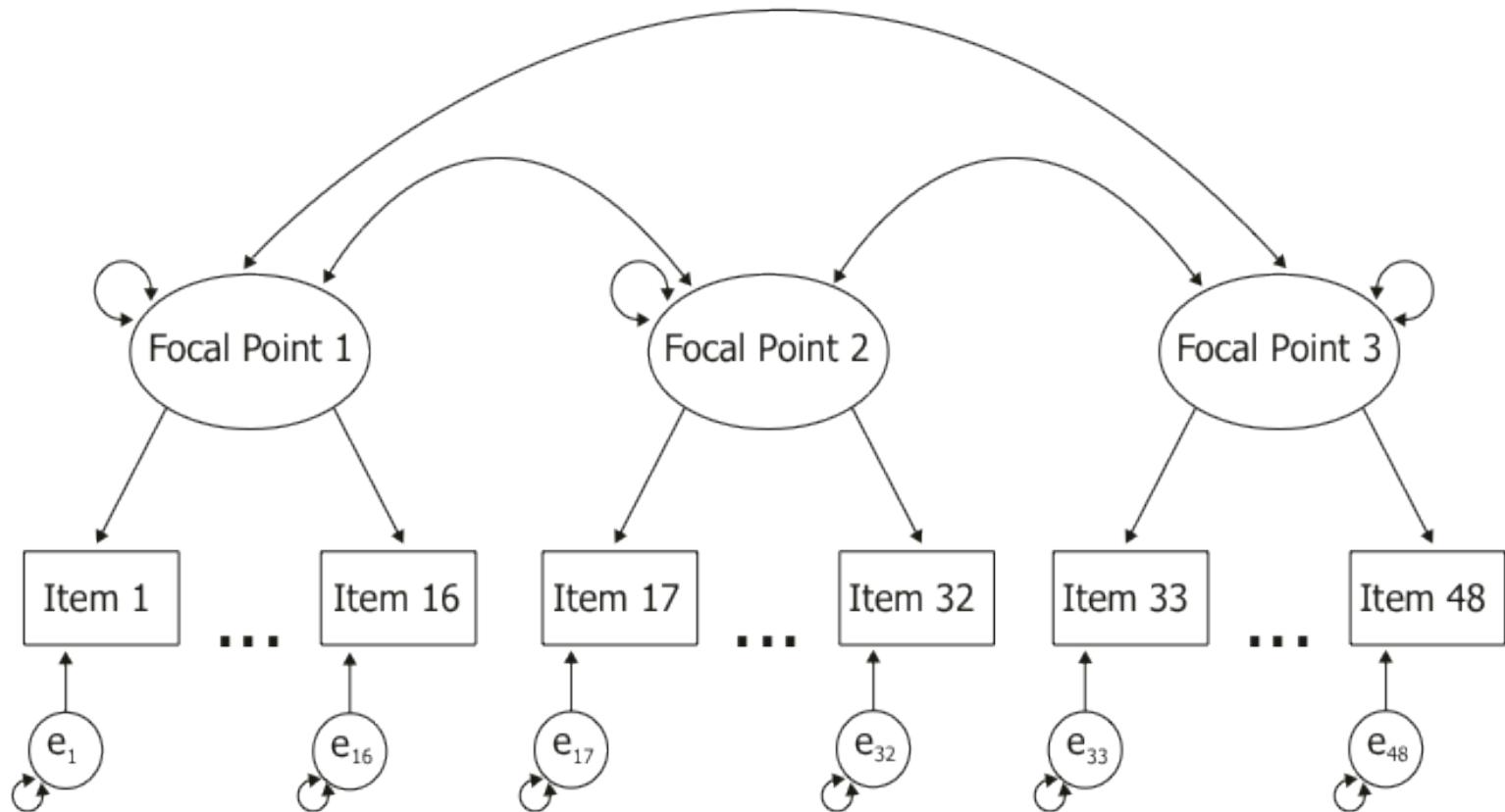| Grade Level	National Council of Teachers of Mathematics Focal Points
Grade 3	Number & Operations & Algebra
	Numbers & Operations
	Geometry
Grade 4	Number & Operations & Algebra
	Numbers & Operations
	Measurement
Grade 5	Number & Operations & Algebra
	Numbers & Operations
	Geometry & Measurement & Algebra

Measurement Model

Example Item
fourth grade - measurement

How many ☐ fit in

?
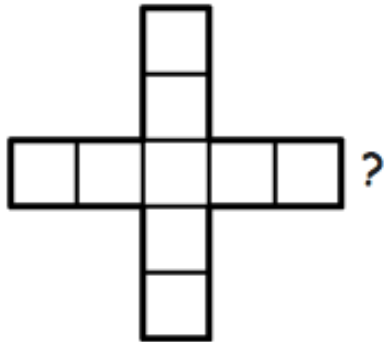
- ○ 7
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- ○ 9

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Methods: Sample

	Fall		Winter	
	n	*%*	*n*	*%*
Grade 3 Fall	*4183*	-	*2800*	-
SpED	301	12	285	13
GenED	2119	88	1935	87
Minority	1392	34	1032	38
Non-minority	2695	66	1698	62
ELL	307	19	256	19
Non-ELL	1268	81	1125	81
Grade 4 Fall	*4111*	-	*2897*	-
SpED	308	14	299	13
GenED	1957	86	1971	87
Minority	1404	35	1101	39
Non-minority	2620	65	1731	61
ELL	233	15	199	14
Non-ELL	1297	85	1265	86
Grade 5 Fall	*4407*	-	*3049*	-
SpED	351	14	310	13
GenED	2178	86	2049	87
Minority	1419	33	1084	37
Non-minority	2855	67	1884	63
ELL	239	14	192	13
Non-ELL	1463	86	1332	87

Methods

- Measurement Invariance
  1) Confirmatory Factor Analyses (CFA)
  2) Configural Invariance
  3) Measurement Invariance

- Differential Item Functioning (DIF)

Methods:
CFA & Configural Invariance

- Confirmatory factor analyses (CFA)
  - tested the fit of the *a priori* model structure, using the entire grade-level sample

- Configural Invariance
  - separately for each group
  - fit indices compared
  - satisfied if the two comparison groups displayed fit indices similar to the CFA and similar to each other
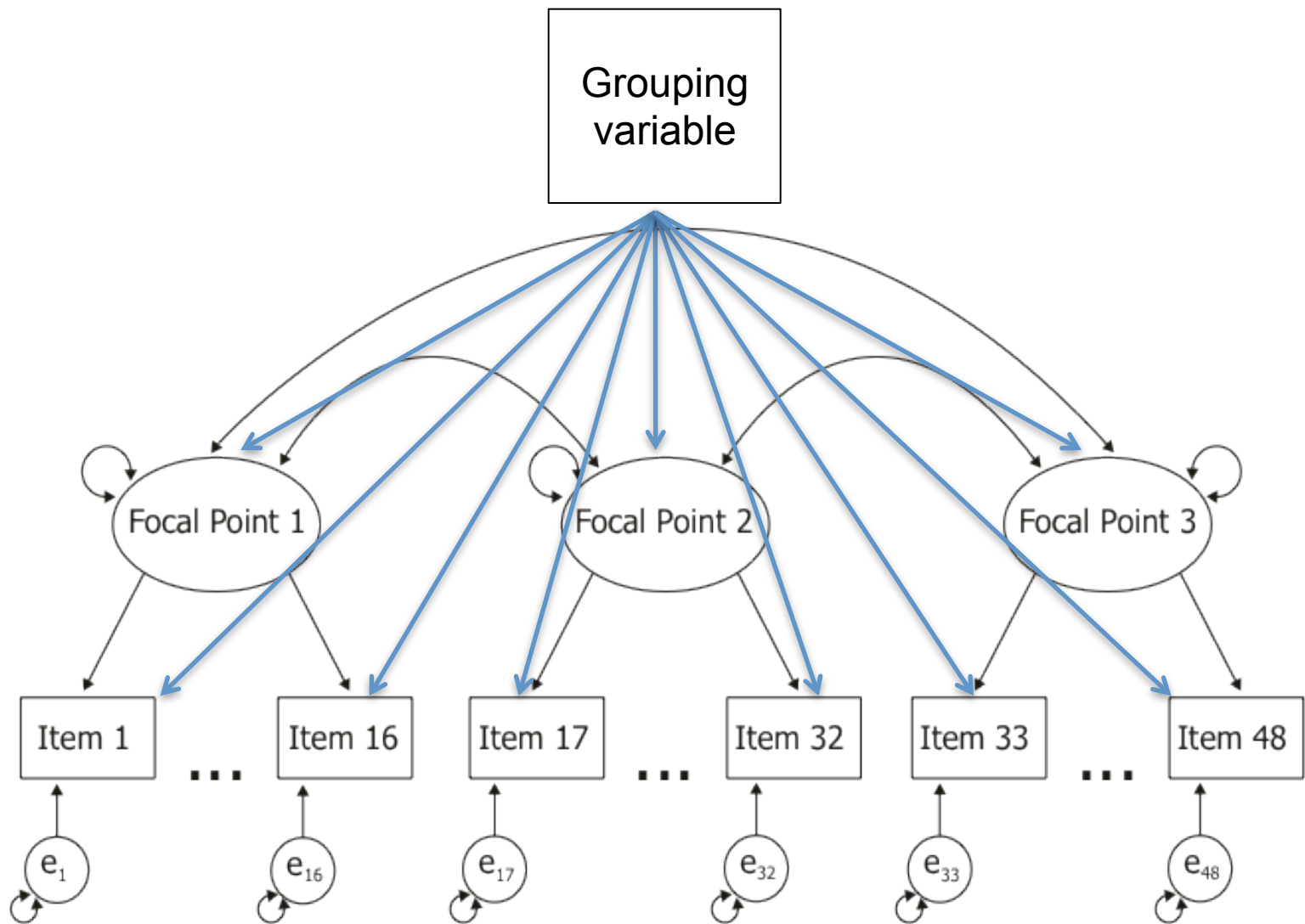
Methods:
Measurement Invariance

- Following the suggestions made by Muthén and Muthén (1998-2007), two models were compared.

	Thresholds/ Factor Loadings	Residual Variances	Factor Means
1) Least Restrictive Model	Free across both groups	Fixed at 1.0 for both groups	Fixed at 0.0 for both groups
2) Most Restrictive Model	Constrained to be equal across both groups	Group 1: fixed at 1.0 Group 2: free	Group 1: fixed at 0.0 Group 2: free

Differential Item Functioning (DIF)

- DIF examines the invariance of the scale at the item level

- DIF is found when students in the comparison groups who are equal in level on the latent trait do not have the same probability of endorsing a test item (Embretson & Reise, 2000).

Abell, Springer, & Kamata (2009)

Methods: DIF

- Following the suggestions made by Abell, Springer, & Kamata (2009), two models were compared.

  1) A full MIMIC DIF: latent variables were regressed on the grouping variable with no restrictions; all items were regressed on the grouping variable (DIF parameters) and constrained to be 0.

     - Modification indices reported by Mplus 5.21 (Muthén & Muthén, 2009) were examined to determine whether any DIF parameters constrained at 0 were suggested to be freely estimated.

  2) All DIF parameters identified by the modification indices were freely estimated in the subsequent model analysis.

Results: CFA & Configural Invariance

Grade 3 CFA and Configural Invariance Model Fit Results

	CFI	TLI	RMSEA
Fall			
3 Factor CFA	.85	.90	.040
SpEd	.88	.89	.033
GenEd	.86	.89	.039
Minority	.88	.91	.040
Non-Minority	.86	.89	.039
ELL	.86	.87	.035
Non-ELL	.89	.91	.038
Winter			
3 Factor CFA	.91	.94	.032
SpEd	.90	.91	.036
GenEd	.91	.93	.030
Minority	.90	.93	.034
Non-Minority	.91	.93	.032
ELL	.75	.78	.040
Non-ELL	.93	.95	.030

Results: CFA & Configural Invariance

Grade 4 CFA and Configural Invariance Model Fit Results

	CFI	TLI	RMSEA
Fall			
3 Factor CFA	.93	.97	.032
SpEd	.85	.87	.043
GenEd	.94	.95	.029
Minority	.94	.95	.031
Non-Minority	.93	.95	.032
ELL	.86	.86	.033
Non-ELL	.93	.94	.032
Winter			
3 Factor CFA	.83	.89	.047
SpEd	.90	.91	.039
GenEd	.86	.88	.041
Minority	.87	.90	.045
Non-Minority	.82	.86	.049
ELL	.81	.82	.038
Non-ELL	.85	.88	.044

Results: CFA & Configural Invariance

Grade 5 CFA and Configural Invariance Model Fit Results

	CFI	TLI	RMSEA
Fall			
3 Factor CFA	.88	.93	.034
SpEd	.85	.87	.032
GenEd	.88	.91	.031
Minority	.90	.92	.031
Non-Minority	.88	.92	.033
ELL	.82	.82	.024
Non-ELL	.90	.92	.030
Winter			
3 Factor CFA	.92	.95	.038
SpEd	.92	.93	.037
GenEd	.91	.93	.037
Minority	.94	.95	.034
Non-Minority	.91	.94	.041
ELL	.83	.84	.033
Non-ELL	.92	.94	.036

Results: Measurement Invariance

	Grade 3		Grade 4		Grade 5	
	Fall *p*-value	Winter *p*-value	Fall *p*-value	Winter *p*-value	Fall *p*-value	Winter *p*-value
Special Education	0.000	0.0000	-	0.000	0.000	0.003
Ethnic Minority	0.000	0.017	0.034	0.004	0.000	0.006
ELL	0.000	-	-	-	-	-

Note. The *p*-value refers to the difference test as specified by the DIFFTEST option in Mplus 5.21 (Muthén & Muthén, 2009) to obtain a correct chi-square difference. Those analyses missing from the tables were excluded because configural invariance was not achieved.

Results: DIF Grade 3

| Math Items | Constrained DIF Parameters | | | | Freely Estimated Indicated DIF Parameters | | | |
	M.I.[a]	E.P.C.[b]	Std. E.P.C.[c]	StdYX E.P.C.[d]	DIF Coefficient	S.E.	Est./S.E.	*p*-value
Fall								
ON Minority/non-minority								
fp33	15.57	-0.46	-0.46	-0.11	-0.31	0.07	-4.13	0.000
fp310	14.79	0.37	0.37	0.10	0.40	0.07	5.67	0.000
fp311	15.46	0.36	0.36	0.10	0.38	0.07	5.74	0.000
Winter								
ON Minority/non-minority								
fp39	16.90	-0.40	-0.40	-0.14	-0.40	0.06	-6.20	0.000
ON ELL/non-ELL								
fp39	14.92	-0.75	-0.75	-0.23	-0.74	0.12	-6.33	0.000

Note. The focal point ("fp") number is indicated by the first numeral after "fp" and the number of the math item associated with that focal point is indicated by the numeral(s) following the focal point.
[a] Modification Index; drop in chi-square value.
[b] Expected Parameter Change.
[c] Standardized E.P.C using variances of the latent variables.
[d] Standardized E.P.C using variances of the latent variables and the outcome variables.

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Results: DIF Grade 4

| Math Items | Constrained DIF Parameters | | | | Freely Estimated Indicated DIF Parameters | | | |
	M.I.[a]	E.P.C.[b]	Std. E.P.C.[c]	StdYX E.P.C.[d]	DIF Coefficient	S.E.	Est./S.E.	p-value
Fall								
ON SpEd/GenEd								
fp15	11.10	0.41	0.41	0.14	0.41	0.09	4.39	0.000
fp213	13.90	1.02	1.02	0.16	1.48	0.28	5.37	0.000
fp214	15.25	1.16	1.16	0.16	1.66	0.31	5.44	0.000
fp216	13.45	-0.63	-0.63	-0.18	-0.33	0.13	-2.70	0.000
fp315	14.80	0.46	0.46	0.15	0.46	0.10	4.81	0.000
Winter								
ON Minority/non-minority								
fp25	17.15	0.32	0.32	0.14	0.32	0.06	5.34	0.000
fp312	13.23	-0.35	-0.35	-0.13	-0.35	0.06	-5.58	0.000

Note. The focal point ("fp") number is indicated by the first numeral after "fp" and the number of the math item associated with that focal point is indicated by the numeral(s) following the focal point.

[a] Modification Index; drop in chi-square value.

[b] Expected Parameter Change.

[c] Standardized E.P.C using variances of the latent variables.

[d] Standardized E.P.C using variances of the latent variables and the outcome variables.

Results: DIF Grade 5

Math Items	Constrained DIF Parameters				Freely Estimated Indicated DIF Parameters			
	M.I.[a]	E.P.C.[b]	Std. E.P.C.[c]	StdYX E.P.C.[d]	DIF Coefficient	S.E.	Est./S.E.	*p*-value
Fall								
ON Minority/non-minority								
fp31	10.56	0.17	0.17	0.08	0.18	0.05	3.82	0.000
fp34	12.44	0.20	0.20	0.08	0.21	0.05	4.33	0.000
fp36	12.80	0.23	0.23	0.09	0.24	0.05	4.53	0.000
fp37	62.08	0.46	0.46	-0.19	-0.41	0.05	-8.70	0.000
fp315	10.64	0.17	0.17	0.07	0.18	0.05	3.99	0.000
ON ELL/non-ELL								
fp37	24.31	-0.70	-0.70	-0.22	-0.70	0.11	-6.49	0.000

Note. The focal point ("fp") number is indicated by the first numeral after "fp" and the number of the math item associated with that focal point is indicated by the numeral(s) following the focal point.

[a] Modification Index; drop in chi-square value.

[b] Expected Parameter Change.

[c] Standardized E.P.C using variances of the latent variables.

[d] Standardized E.P.C using variances of the latent variables and the outcome variables.

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Discussion

- Exploratory Factor Analyses (EFA) or modification indices to improve model structure compared to *a priori* model?
  - Improved fit in CFA analyses
  - Consequently change results of measurement invariance analyses?
- Test for partial measurement invariance by relaxing some of the thresholds/factor loadings equality constraints
- Few items identified as DIF
  - How does that affect measurement invariance?

References

Abell, N., Springer, D. W., & Kamata, A. (2009). *Developing and validating rapid assessment instruments*. New York: Oxford University Press, Inc.

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Muthén, L. K., & Muthén, B. O. (1998-2007). *Mplus User's Guide* (Fifth ed.). Los Angeles: Authors.

Muthén, L. K., & Muthén, B. O. (2009). Mplus version 5.21 [computer software]. Los Angeles: Authors.

For More Information

http://brt.uoregon.edu

http://easyCBM.com