APPENDIX T

CONFIRMATORY FACTOR ANALYSES OF THE MAY 2019 ADMINISTRATION DATA

Confirmatory Factor Analyses of the May 2019 Administration Data

Item-level confirmatory factor analysis (CFA) was utilized to assess the internal structure of the MCAS ELA and Mathematics assessments in grade 10 from the School Year 18-19.

The R package “lavaan” (Oberski, 2014) was used to estimate the inter-item polychoric correlations and item thresholds, and to fit the CFA model for each subject area.

The CFA model for each test was specified such that the number of factors equaled the number of reporting categories and each item loaded onto the factor that corresponded to the reporting category to which the given item contributed. Each example, for ELA Grade 10, the subset of items that contributed to Reporting Category 1 loaded onto Factor 1, the subset of items that contributed to Reporting Category 2 loaded onto Factor 2, and the subset of items that contributed to Reporting Category 3 loaded onto Factor 3. Table 1 contains details on the reporting categories for each subject area and grade.

Table 1. Reporting Categories Summary for MCAS 18-19 ELA and Mathematics, Grade 10

Subject Area	Grade	Number of Items	Number of Reporting Categories
ELA	10	32	3
Math	10	42	4

Parameters for CFA were estimated in *lavaan* using a weighted least-square method with mean and variance adjustment (Muthén, du Toit, & Spisic, 1997). This method leads to a consistent estimator of the model parameters and provides standard errors that are robust under model misspecification. For ordinal data, weighted least squares estimation offers an alternative to full-information maximum likelihood techniques. The latter becomes computationally too demanding for models with more than a few dimensions. Model fit is assessed through a scaled chi-square statistic. However, the degrees of freedom for the reference distribution of this statistic cannot be computed in the standard way. The correct degrees of freedom depend on the data, and hence degrees of freedom may vary when the same model is applied to different data (Muthén, 1998–2004, p. 19-20).

Overall model fit for the CFA model was examined using the scaled chi-square (χ^2) test of model fit in combination with supplemental fit indices. The Tucker-Lewis Index (TLI) compares the chi-square for the hypothesized model with that of the null or “independence” model, in which all correlations or covariances are zero. TLI values range from 0.0 to 1.0; values greater than 0.94 signify good fit (Hu & Bentler, 1999). The comparative fit index (CFI) and root mean square error of approximation (RMSEA) index both are based on non-centrality parameters. The CFI compares the covariance matrix predicted by the model with the observed covariance matrix, and the covariance matrix of the null model with the observed covariance matrix. A CFI value greater than 0.90 indicates acceptable model fit (Hu & Bentler, 1999). The RMSEA assesses the error in the hypothesized model predictions; values less than or equal to 0.06 indicate good fit (Hu & Bentler, 1999).

A summary of results on model fit and factor correlation in each grade and subject is presented in Table 2. Detailed standardized factor loading and factor correlation results are presented in the Appendix A. Table 2 shows that CFI or TLI indices indicate acceptable or good model fit for all tests. However, all estimated between-factor correlations are very high for all grades and subjects. In particular, in Grade 10 ELA, the estimated correlation between Factors 2 and 3 that was greater than 1.0; in Grade 10 Math, the estimated correlation between Factors 1 & 2 was slightly above 1.0. Estimated correlations above 1 can occur when factors are so highly correlated that it causes estimation problems. This suggests that the factors are highly intercorrelated, as is the case when the test is essentially unidimensional. In other words, different factors are essentially measuring the same thing. These results are consistent with CFA analyses conducted on 2018 MCAS ELA and Mathematics tests in grades 3-8, suggesting that the MCAS tests in these grades are essentially unidimensional.

Table 2. Results Summary of Confirmatory Factor Analyses

Content Area	Grade	*N*	# of Item	# of Factor	Chi Sq.	*df*	*p*	CFI	TLI	RMSEA	Min Factor *r*	Max Factor *r*
ELA	10	67,067	32	3	53622.43	461	<0.00001	1.000	1.000	0.041	***1.343***	0.790
Mathematics	10	64,481	42	4	17655.10	813	<0.00001	0.998	0.997	0.018	***1.017***	0.955

Note. Cells in red font indicate the maximum factor correlation exceeded 1.0 in the given subject/grade. CFI = Comparative Fit Index, TLI = Tucker-Lewis Index, RMSEA = Root Mean Squared Error of Approximation, Min Factor *r* = Minimum Factor Correlation, Max Factor *r* = Maximum Factor Correlation.

REFERENCES

Browne, M.W., & Cudeck, R. (1993). Alternative ways of assessing model fit. In K. Bollen & J. Long (Eds.), *Testing Structural Equation Models* (pp. 136 – 162). Newbury Park, CA: Sage Publications.

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling*, *6*, 1–55.

Daniel Oberski (2014). Lavaan.survey: an R package for complex survey analysis of structural equation models. *Journal of Statistical Software*, *57(1)*, 1-27. http://www.jstatsoft.org/v57/i01/.

Appendix A.
Standardized Factor Loadings in Each Subject and Grade

Table A1. Standardized Factor Loadings and Factor Correlations in ELA10

Factor	Item	Factor Loading	Factor Loading SE
F1	IA01801	0.513	0.007
F1	IA01796	0.619	0.005
F1	IA01790	0.492	0.005
F1	IA01786	0.508	0.005
F1	IA01771	0.658	0.005
F1	IA01417	0.720	0.004
F1	IA01412	0.513	0.005
F1	IA01402	0.597	0.004
F1	IA01406	0.539	0.005
F1	IA01413	0.711	0.005
F1	IA01628	0.548	0.006
F1	IA01629	0.633	0.005
F1	IA01635	0.812	0.005
F1	IA01805	0.493	0.005
F1	IA01631	0.780	0.004
F1	IA01326	0.635	0.005
F1	IA01327	0.561	0.005
F1	IA01331	0.536	0.006
F1	IA01775	0.750	0.003
F1	IA01803	0.435	0.004
F1	IA01420	0.597	0.003
F1	IA01404	0.584	0.003
F1	IA01637	0.691	0.005
F1	IA01641	0.679	0.004
F1	IA01764	0.726	0.003
F2	IA01802	0.334	0.005
F2	IA01403	0.623	0.005
F2	IA01632	0.636	0.005
F2	IA01785A	0.872	0.001
F2	IA01407A	0.865	0.001
F3	IA01785D	0.845	0.001
F3	IA01407D	0.855	0.001

Factor	Factor	Factor Correlation	Factor Correlation SE
F1	F2	0.883	0.002
F1	F3	0.790	0.002
F2	F3	***1.343***	0.003

Note. Factor correlations whose estimates were greater than 1.000 are displayed in red.

Table A2. Standardized Factor Loadings and Factor Correlations in Math10

Factor	Item	Factor Loading	Factor Loading SE
F1	IA02139	0.597	0.004
F1	IA02837	0.646	0.003
F1	IA02864	0.602	0.004
F1	IA04586	0.779	0.002
F2	IA02336	0.656	0.004
F2	IA02317	0.693	0.004
F2	IA02489	0.660	0.004
F2	IA02488	0.781	0.003
F2	IA02318	0.522	0.004
F2	IA02290	0.322	0.005
F2	IA04738	0.505	0.005
F2	IA02790	0.828	0.002
F2	IA04532	0.715	0.003
F2	IA02785	0.754	0.003
F2	IA02868	0.496	0.004
F2	IA02780	0.818	0.003
F2	IA02784	0.782	0.004
F2	IA02835	0.770	0.002
F2	IA02807	0.726	0.003
F2	IA04546	0.871	0.001
F3	IA04675	0.724	0.003
F3	IA04519	0.705	0.003
F3	IA04677	0.637	0.004
F3	IA04518	0.657	0.004
F3	IA04536	0.522	0.004
F3	IA02640	0.496	0.004
F3	IA04597	0.620	0.004
F3	IA02625	0.573	0.004
F3	IA02631	0.474	0.004
F3	IA02634	0.689	0.004
F3	IA04732	0.444	0.004
F3	IA04499	0.738	0.003
F3	IA02961	0.678	0.003
F3	IA02802	0.770	0.003
F3	IA02845	0.536	0.005
F3	IA02846	0.752	0.003
F3	IA02855	0.804	0.002
F4	IA02362	0.554	0.004
F4	IA04730	0.592	0.004
F4	IA02816	0.625	0.005
F4	IA02854	0.634	0.003
F4	IA04574	0.826	0.002

Factor	Factor	Factor Correlation	Factor Correlation SE
F1	F2	***1.017***	0.002
F1	F3	0.993	0.002
F1	F4	0.993	0.003
F2	F3	0.969	0.001
F2	F4	0.964	0.002
F3	F4	0.955	0.002

Note. Factor correlations whose estimates were greater than 1.000 are displayed in red.