



Workshop 2

SCALE DEVELOPMENT AND VALIDATION IN PRACTICE

Samson Shen, Msc, FHEA
Email: samson66@hku.hk

Acknowledgement: Some slides in this presentation were adapted from workshop materials by Prof. Fred Ganotice and Mr. John Ian Wilzon Dizon.

WORKSHOP FLOW



Brief recap of Exploratory Factor analysis (EFA) and Confirmatory Factor Analysis (CFA)

CFA in SPSS AMOS: model building, interpretation and gender invariance practice

LEARNING OUTCOMES



1. Explain the purpose of EFA and CFA in scale development and validation.
2. Conduct and interpret CFA in AMOS, including basic multi-group measurement invariance testing, through hands-on activities.

What are EFA and CFA?

- Exploratory Factor Analysis (EFA)**

Finds a structure

Data-driven. Explores possible factor numbers and item patterns.



Name of Factor 1: _____

Item 8 My father thinks that I am bright enough to go on to college or university.
Item 15 If I decided to go on to college or university, my father would encourage me.
Item 26 My mother thinks that I am bright enough to go on to college or university.
Item 37 If I decided to go on to college or university, my mother would encourage me.
Item 47 My parents are supportive of my university aspirations.
Item 52 My parents support me of reaching my dreams.

Name of Factor 2: _____

Item 5 Most of my friends want to do well at school.
Item 17 Most of my friends want to go on to college.
Item 28 Working with my friends at school improves my schoolwork.
Item 39 It is important for me to have my friends' help with schoolwork.

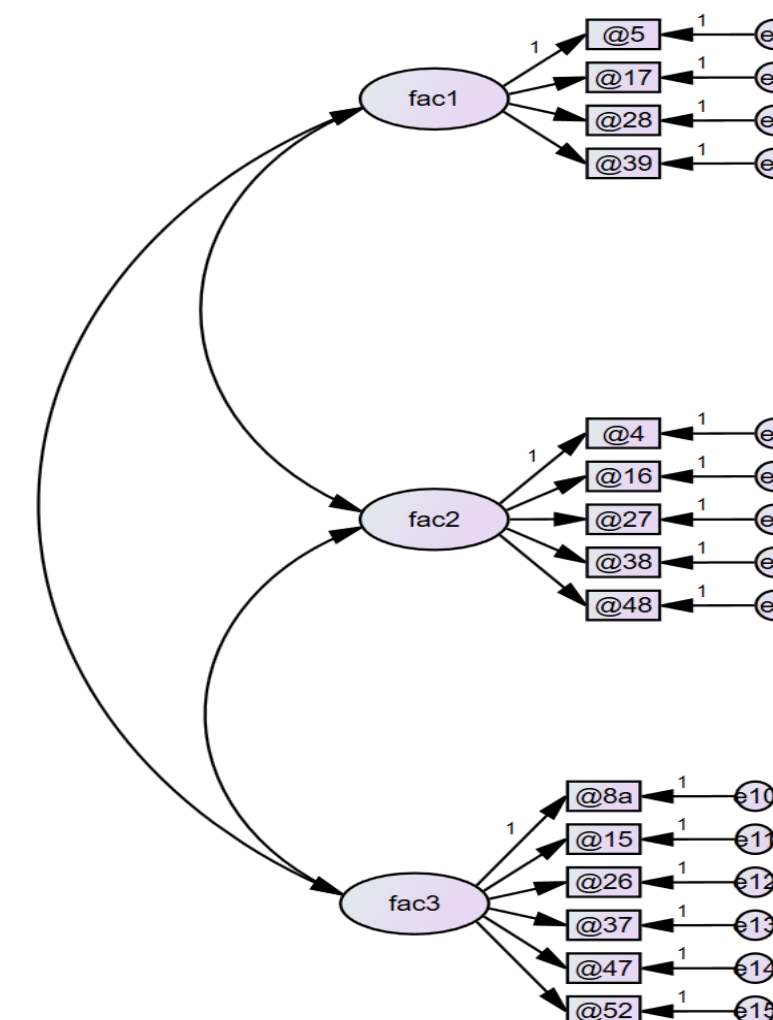
Name of Factor 3: _____

Item 4 I get encouragement from some of my teachers to do well at school.
Item 16 If I decided to go on to college or university, teachers at this school would encourage me.
Item 27 Some of my teachers tell me I am bright enough to go on to college or university.
Item 38 Teachers are positive to me in school.
Item 48 My teacher help me with my school work.

- Confirmatory Factor Analysis (CFA)**

Tests a structure

Theory-driven. The factors and their items are set in advance, then tested for fit.





CFA IN SPSS AMOS: TUTORIAL AND HANDS-ON ACTIVITY

WHY CFA MATTERS

Use a developed questionnaire with stronger evidence

Check whether its proposed structure works with your participants.

Develop a validation study

Adapting an existing questionnaire for a new language or population may offer a research opportunity when there is a clear need.

Examples from our team



Annals of Medicine

ISSN: 0785-3890 (Print) 1365-2060 (Online) journal homepage: www.tandfonline.com/journals/lam20

Psychometric validation of the Physician Well-Being Index-Expanded (ePWBI) among physician educators in Hong Kong

Linda Chan, Paul Po Ling Chan, Xiaoli Shen, Emma Victoria Marianne Bilne Tai Pong Lam, Julie Yun Chen, George L. Tipoe & Fraide A. Ganotice

To cite this article: Linda Chan, Paul Po Ling Chan, Xiaoli Shen, Emma Victoria Marianne Bilne Tai Pong Lam, Julie Yun Chen, George L. Tipoe & Fraide A. Ganotice (2025) Psychometric validation of the Physician Well-Being Index-Expanded (ePWBI) among physician educators in Hong Kong, *Annals of Medicine*, 57:1, 2532121, DOI: [10.1080/07853890.2025.2532121](https://doi.org/10.1080/07853890.2025.2532121)

To link to this article: <https://doi.org/10.1080/07853890.2025.2532121>

© 2025 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group

View supplementary material

Published online: 16 Jul 2025.

Submit your article to this journal

Article views: 1318

View related articles

View Crossmark data

Citing articles: 1 View citing articles





Annals of Medicine

ISSN: 0785-3890 (Print) 1365-2060 (Online) journal homepage: www.tandfonline.com/journals/lam20

Students' interaction anxiety and social phobia in interprofessional education in Hong Kong: mapping a new research direction

Fraide A. Ganotice Jr, Xiaoli Shen, Jacqueline Kwan Yuk Yuen, Yin Man Amy Chow, Anita M. Y. Wong, Karen M. K. Chan, Binbin Zheng, Linda Chan, Pauline Yeung Ng, Siu Chung Leung, Elizabeth Barrett, Hoi Yan Cella Chan, Wing Nga Chan, Kit Wa Sherry Chan, Siu Ling Polly Chan, So Ching Sarah Chan, Esther W. Y. Chan, Yuet Ying Jessica Cheuk, Jacky Choy, Qing He, Julianne Jen, Jingwen Jin, Li Soon Khoo, Ho Yan Angie Lam, May P. S. Lam, Yik Wa Law, Jetty Chung Yung Lee, Feona Chung Yin Leung, Ann Leung, Rebecca K. W. Liu, Vivian Wei Qun Lou, Pauline Luk, Zoe Lai Han Ng, Alina Yee Man Ng, Maggie Wai Ming Pun, Mary Lok Man See, Jangang Shen, Grace Pui Yuk Szeto, Eliza Y. T. Tam, Winnie Wan Yee Tso, Ning Wang, Runlia Wang, Janet Kit Ting Wong, Janet Yuen Ha Wong, Grace Wai Yee Yuen & George Lim Tipoe

To cite this article: Fraide A. Ganotice Jr, Xiaoli Shen, Jacqueline Kwan Yuk Yuen, Yin Man Amy Chow, Anita M. Y. Wong, Karen M. K. Chan, Binbin Zheng, Linda Chan, Pauline Yeung Ng, Siu Chung Leung, Elizabeth Barrett, Hoi Yan Cella Chan, Wing Nga Chan, Kit Wa Sherry Chan, Siu Ling Polly Chan, So Ching Sarah Chan, Esther W. Y. Chan, Yuet Ying Jessica Cheuk, Jacky Choy, Qing He, Julianne Jen, Jingwen Jin, Li Soon Khoo, Ho Yan Angie Lam, May P. S. Lam, Yik Wa Law, Jetty Chung Yung Lee, Feona Chung Yin Leung, Ann Leung, Rebecca K. W. Liu, Vivian Wei Qun Lou, Pauline Luk, Zoe Lai Han Ng, Alina Yee Man Ng, Maggie Wai Ming Pun, Mary Lok Man See, Jangang Shen, Grace Pui Yuk Szeto, Eliza Y. T. Tam, Winnie Wan Yee Tso, Ning Wang, Runlia Wang, Janet Kit Ting Wong, Janet Yuen Ha Wong, Grace Wai Yee Yuen & George Lim Tipoe (2023) Student's interaction anxiety and social phobia in interprofessional education in Hong Kong: mapping a new research direction, *Annals of Medicine*, 55:1, 2210842, DOI: [10.1080/07853890.2023.2210842](https://doi.org/10.1080/07853890.2023.2210842)

To link to this article: <https://doi.org/10.1080/07853890.2023.2210842>

© 2023 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group

View supplementary material

Published online: 11 May 2023.

Submit your article to this journal

Article views: 6059

View related articles



Check for updates

ROE Report

Assessing AI-Driven Metacognitive Offloading: Initial Development and Validation of the Metacognitive Laziness Scale

John Ian Wilson T. Dizon¹, Norman B. Mendoza², Dragan Gasevic^{1,3}, and Fraide A. Ganotice Jr.¹

Keywords
Confirmatory factor analysis, generative artificial intelligence, metacognitive laziness, scale development, scale validation

Received: October 26, 2025; revised: January 28, 2026; accepted: March 13, 2026

ECNU Review of Education
2026, Vol. 9(2) 1-12
© The Author(s) 2026
Article reuse guidelines:
sagepub.com/journalsPermissions
DOI: [10.1177/20963311261450994](https://doi.org/10.1177/20963311261450994)
journals.sagepub.com/home/roe





LKS Faculty of Medicine
Bau Institute of Medical & Health Sciences Education

THE DATASET



Our practice model: Use the three-factor model here to guide our CFA (see learning materials for details).

Please download the dataset and save it in a folder:
<https://bit.ly/scaleworkshop2>

Parent support

Name of Factor 1:

- Item 8 My father thinks that I am bright enough to go on to college or university.
- Item 15 If I decided to go on to college or university, my father would encourage me.
- Item 26 My mother thinks that I am bright enough to go on to college or university.
- Item 37 If I decided to go on to college or university, my mother would encourage me.
- Item 47 My parents are supportive of my university aspirations.
- Item 52 My parents support me of reaching my dreams.

Peer support

Name of Factor 2:

- Item 5 Most of my friends want to do well at school.
- Item 17 Most of my friends want to go on to college.
- Item 28 Working with my friends at school improves my schoolwork.
- Item 39 It is important for me to have my friends' help with schoolwork.

Teacher support

Name of Factor 3:

- Item 4 I get encouragement from some of my teachers to do well at school.
- Item 16 If I decided to go on to college or university, teachers at this school would encourage me.
- Item 27 Some of my teachers tell me I am bright enough to go on to college or university.
- Item 38 Teachers are positive to me in school.
- Item 48 My teacher help me with my school work.

BEFORE RUNNING CFA: ASSUMPTIONS

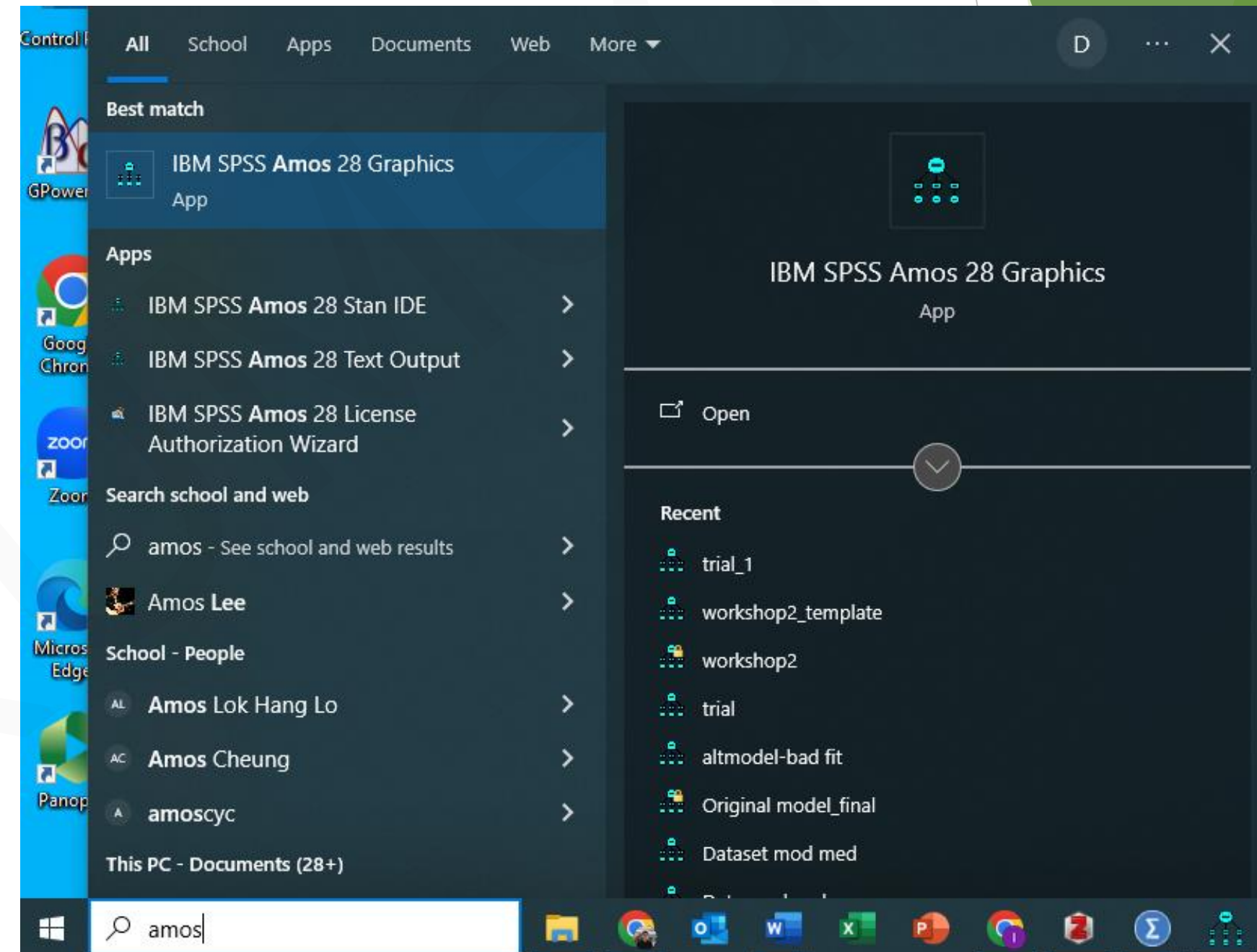
1. **Use the correct data:** e.g., the 15 continuous items in this workshop.
2. **Check the participants:** General Minimum ($N \geq 200$) . Each row should represent one person, with responses independent of other participants.
3. **Check the sample size:** Our practice file has 1,669 participants. Other studies may need different sample sizes.
4. **Use the planned model:** Link each item to its proposed factor: e.g., Parent, Peer or Teacher Support.
5. **Check normality:** Follow the AMOS steps on the next slides before interpreting the maximum likelihood (ML) results.

STEP-BY-STEP PROCESS



STEP 1

- Open the **IBM SPSS AMOS** program.



THE DATASET



Our practice model: Use the three-factor model here to guide our CFA (see learning materials for details).

Name of Factor 1: Parent support

Item 8 My father thinks that I am bright enough to go on to college or university.

Item 15 If I decided to go on to college or university, my father would encourage me.

Item 26 My mother thinks that I am bright enough to go on to college or university.

Item 37 If I decided to go on to college or university, my mother would encourage me.

Item 47 My parents are supportive of my university aspirations.

Item 52 My parents support me of reaching my dreams.

Name of Factor 2: Peer support

Item 5 Most of my friends want to do well at school.

Item 17 Most of my friends want to go on to college.

Item 28 Working with my friends at school improves my schoolwork.

Item 39 It is important for me to have my friends' help with schoolwork.

Name of Factor 3: Teacher support

Item 4 I get encouragement from some of my teachers to do well at school.

Item 16 If I decided to go on to college or university, teachers at this school would encourage me.

Item 27 Some of my teachers tell me I am bright enough to go on to college or university.

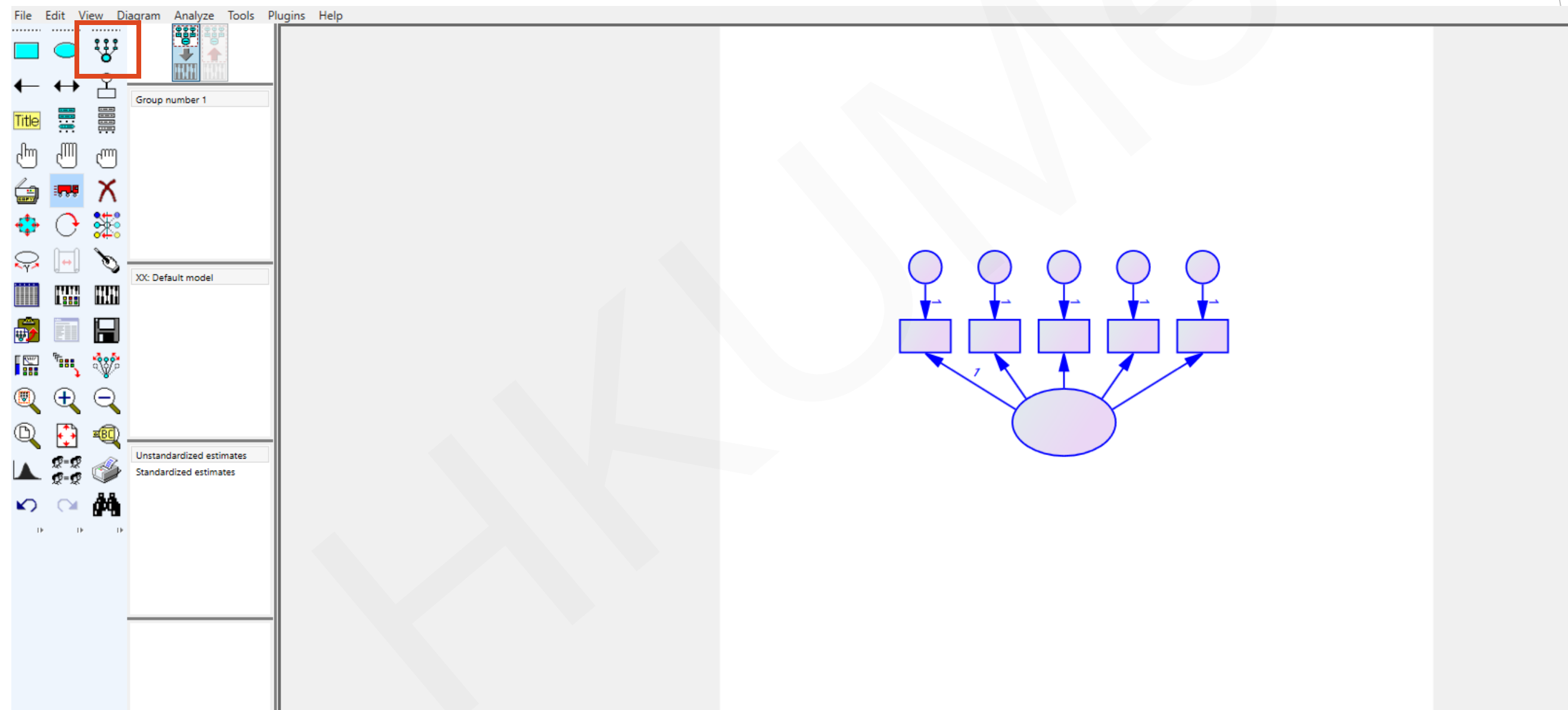
Item 38 Teachers are positive to me in school.

Item 48 My teacher help me with my school work.

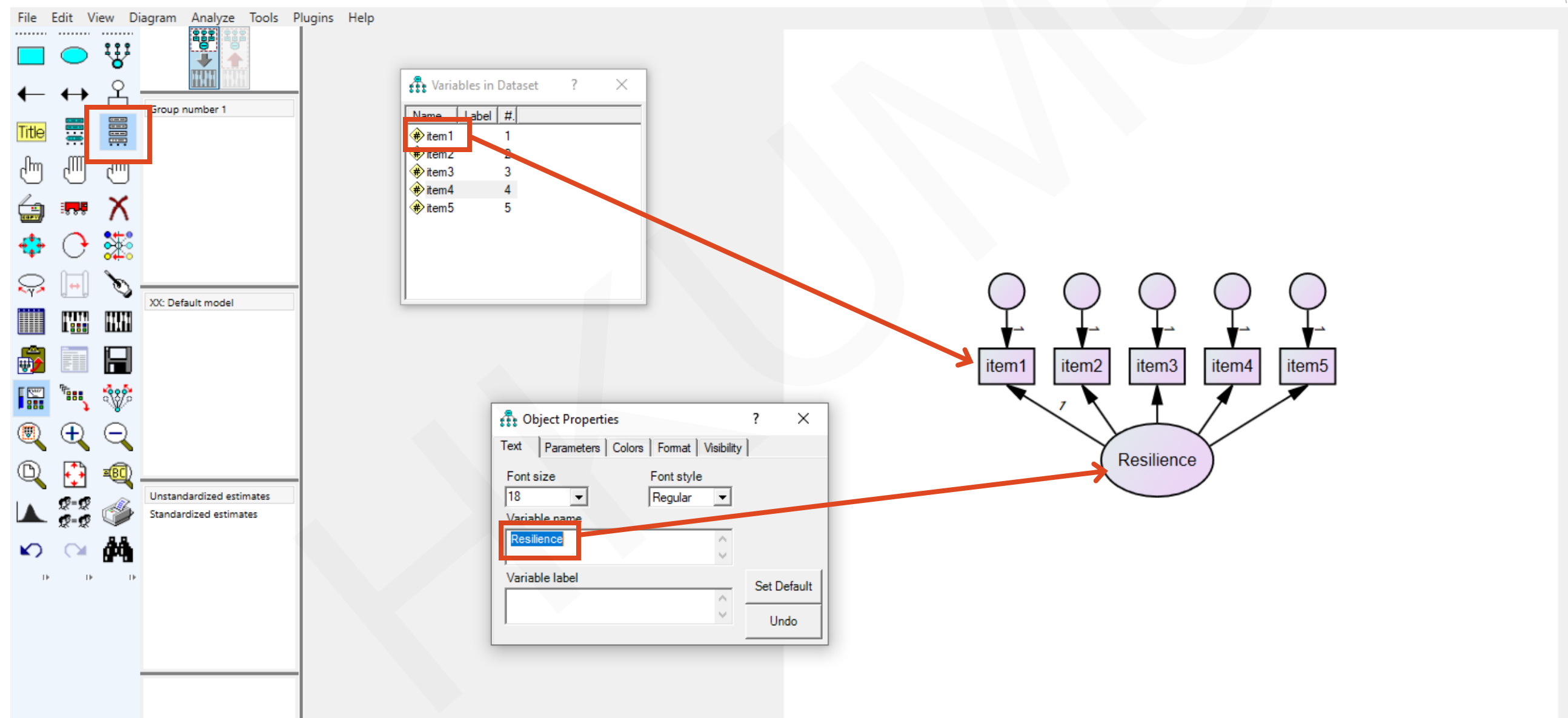
STEP 3



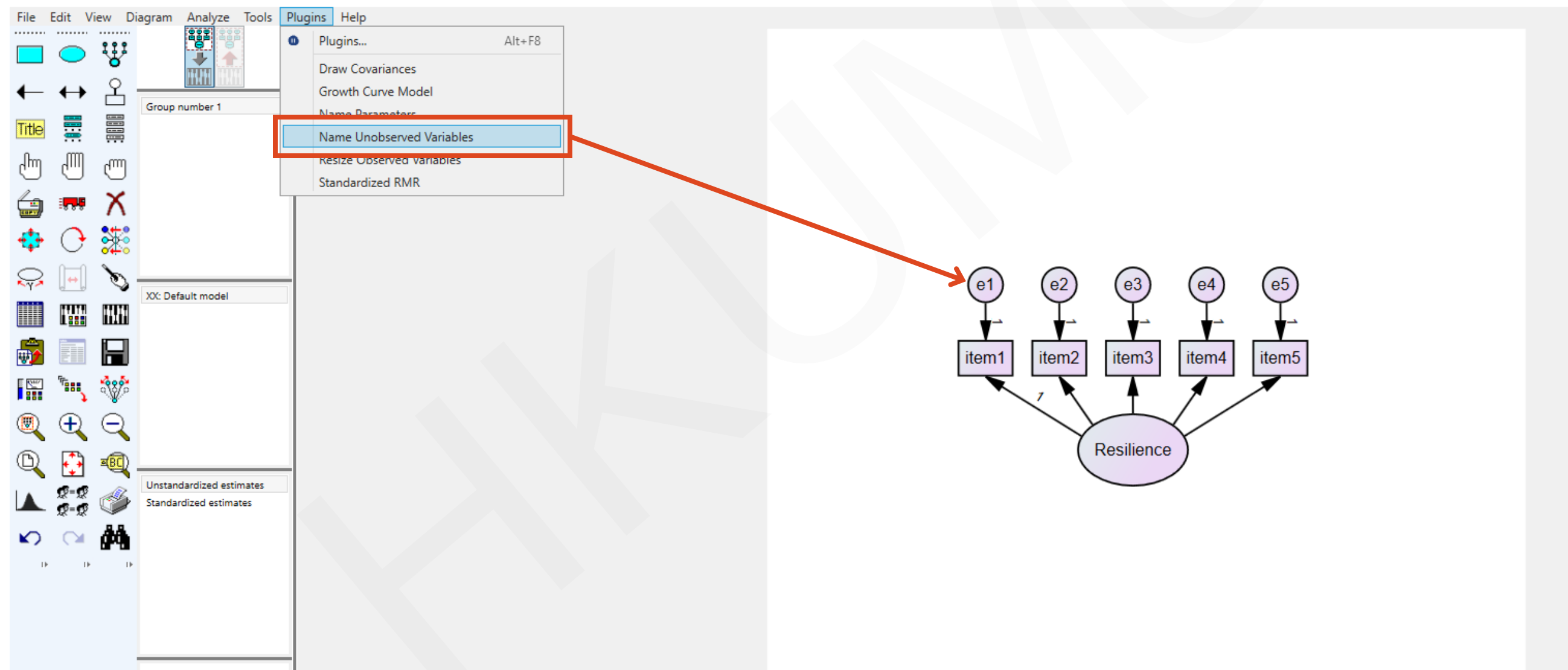
- Create/draw the model using the  “Draw latent variables and indicators”



- Click “**View variables in Dataset**” and name the observed and latent variables



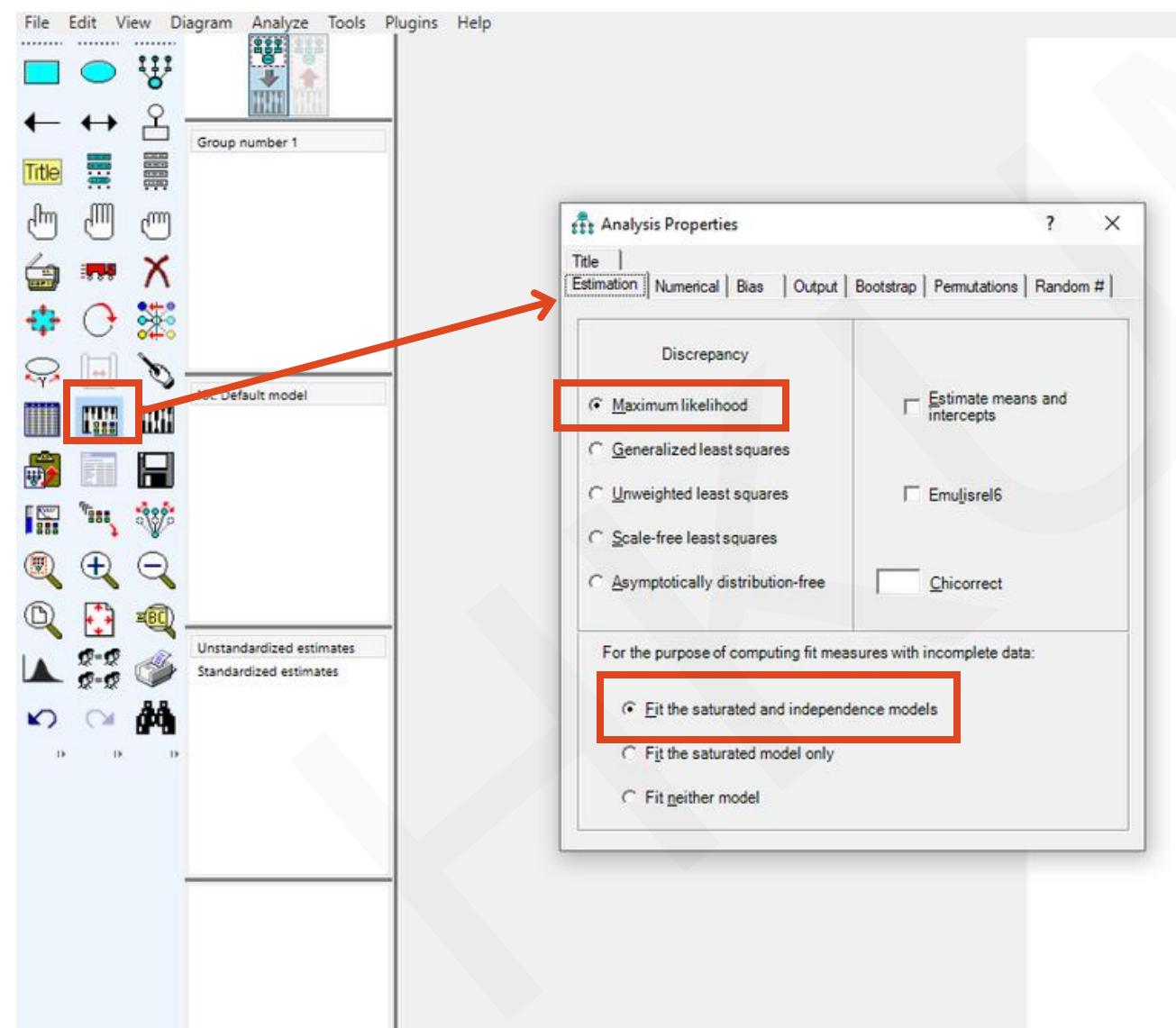
- Click “**Plugins > Name Unobserved Variables**” to label the measurement error terms



STEP 6



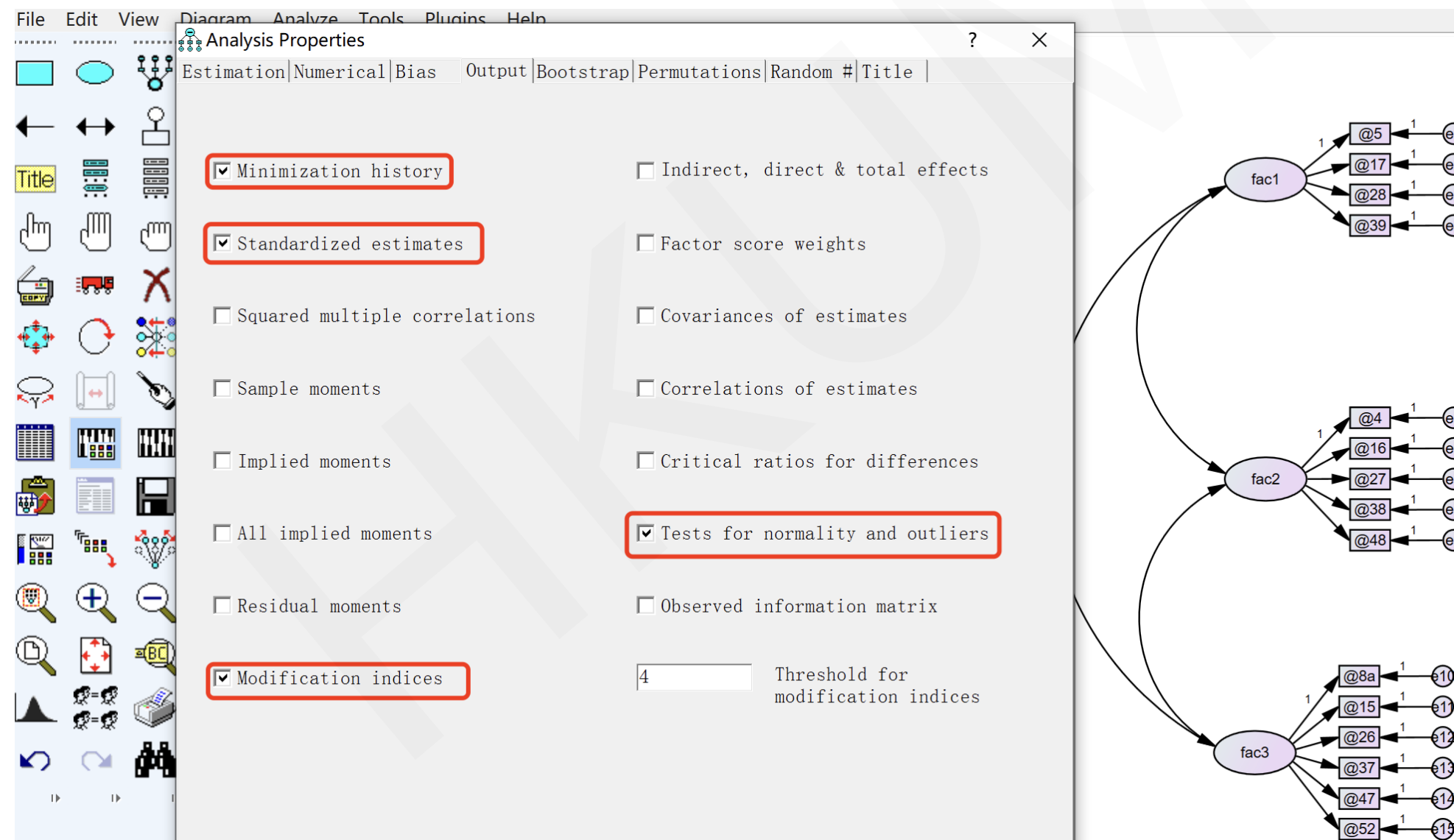
- Click “**Analysis Properties**” to set which estimation method and output elements will be used and shown in the analysis and results



STEP 6 CONT.



- On the **Output tab**, check the boxes for “Minimization history”, “Standardized estimates”, “Modification indices” and “Tests for normality and outliers”. And then, click **Calculate Estimates** button to run CFA



MULTIVARIATE NORMALITY: THE RESULT

1. Find the value:

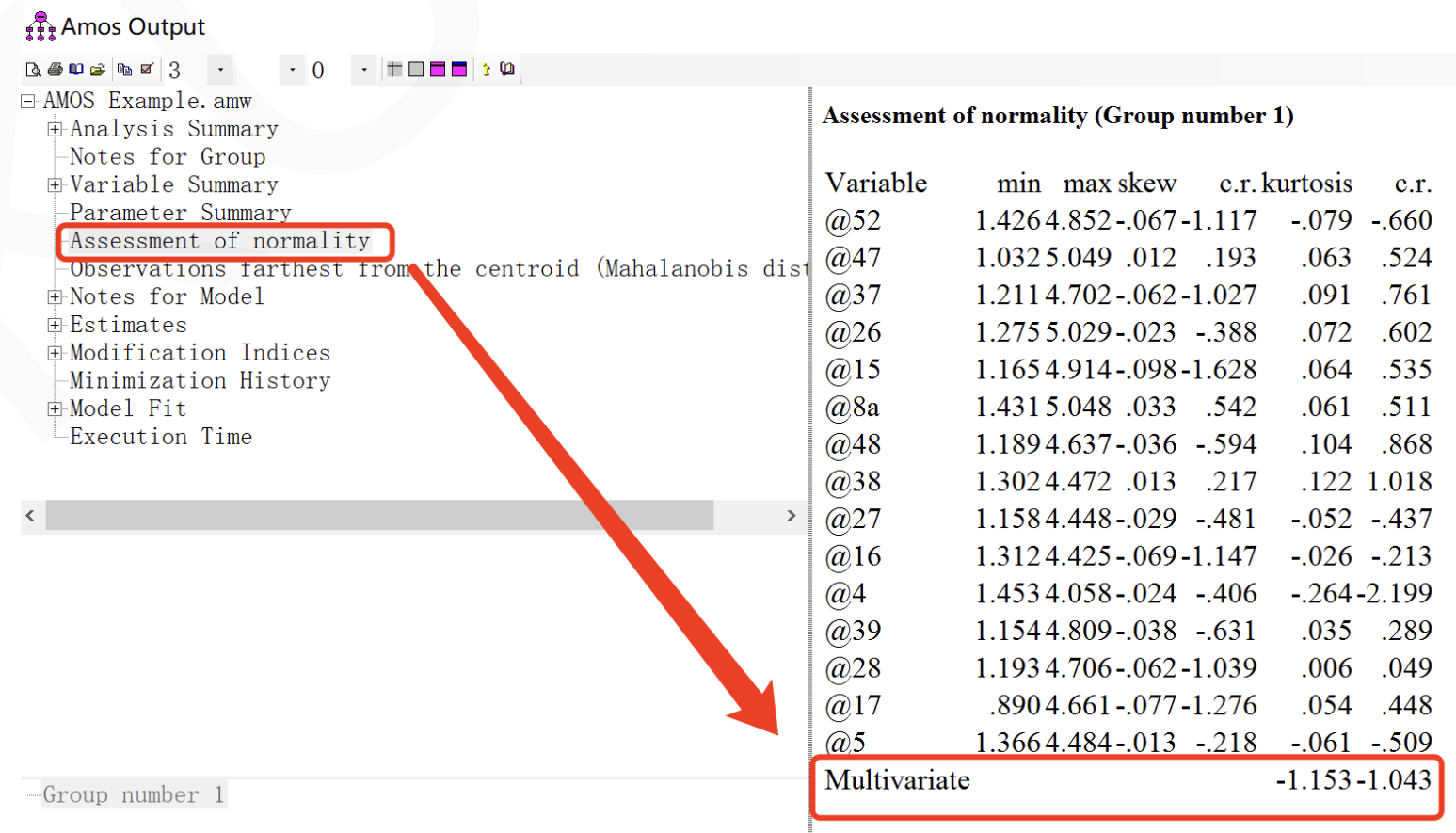
In AMOS output, open **Assessment of normality**. Find the bottom **Multivariate** row and read the last **c.r.** column.

Note. *c.r.* =critical ratio. It standardises the departure in multivariate kurtosis.

2. Interpret the value:

Between -1.96 and $+1.96$: No warning from this check.

Below -1.96 or above $+1.96$: A warning. Review the data and analysis approach before interpreting ordinary ML results.



Amos Output

AMOS Example.amw

- Analysis Summary
- Notes for Group
- Variable Summary
- Parameter Summary
- Assessment of normality**
- Observations farthest from the centroid (Mahalanobis dist)
- Notes for Model
- Estimates
- Modification Indices
- Minimization History
- Model Fit
- Execution Time

Assessment of normality (Group number 1)

Variable	min	max	skew	c.r.	kurtosis	c.r.
@52	1.426	4.852	-.067	-1.117	-.079	-.660
@47	1.032	5.049	.012	.193	.063	.524
@37	1.211	4.702	-.062	-1.027	.091	.761
@26	1.275	5.029	-.023	-.388	.072	.602
@15	1.165	4.914	-.098	-1.628	.064	.535
@8a	1.431	5.048	.033	.542	.061	.511
@48	1.189	4.637	-.036	-.594	.104	.868
@38	1.302	4.472	.013	.217	.122	1.018
@27	1.158	4.448	-.029	-.481	-.052	-.437
@16	1.312	4.425	-.069	-1.147	-.026	-.213
@4	1.453	4.058	-.024	-.406	-.264	-2.199
@39	1.154	4.809	-.038	-.631	.035	.289
@28	1.193	4.706	-.062	-1.039	.006	.049
@17	.890	4.661	-.077	-1.276	.054	.448
@5	1.366	4.484	-.013	-.218	-.061	-.509
Multivariate					-1.153	-1.043

Group number 1

FIT INDICES: MEANINGS AND READING GUIDES

Fit index	Brief meaning	Reading guide
Chi-square (CMIN)	Tests whether the model matches the relationships in the population exactly.	$p > .050$: exact fit is not rejected. Read other indices too.
GFI Goodness-of-Fit Index	Summarises how closely the model reproduces the observed data.	Higher is better. Use as a supporting index.
CFI Comparative Fit Index	Compares our model with a model in which the items are unrelated.	Higher is better. $\geq .900$: older, lenient guide. Around .950: stricter guide.
TLI Tucker–Lewis Index	Like CFI, Compares our model with a model in which items are unrelated, while taking model complexity into account.	Higher is better. $\geq .900$: older, lenient guide. Around .950: stricter guide.
RMSEA Root Mean Square Error of Approximation	Estimates remaining model error, taking degrees of freedom into account.	Lower is better. $< .080$: reasonable-fit guide. Around .060: stricter guide. Read the 90% CI.
SRMR Standardized Root Mean Square Residual	Summarises the standardised gaps between observed and model-predicted relationships.	Lower is better. $< .080$ is a common guide.

WHAT AFFECTS THE FIT INDICES?

Fit index	What can affect the result?
Chi-square (CMIN)	With a large sample, even small differences between the model and the data can give $p < .050$.
GFI	Sample size and model complexity can affect it. Use it as a supporting index.
CFI	Can be lower when the items are only weakly related to each other.
TLI	Can decrease if we add more links without improving the model enough.
RMSEA	Can look too high when there are few degrees of freedom, especially with a small sample.
SRMR	Incorrect or missing links can increase SRMR because the model does not match the relationships between items well.

Sample size: more participants can improve precision. They do not automatically repair an incorrect factor model.

Shi et al., (2019); Maydeu-Olivares, (2017); Kenny et al., (2015)



**HKU
Med**

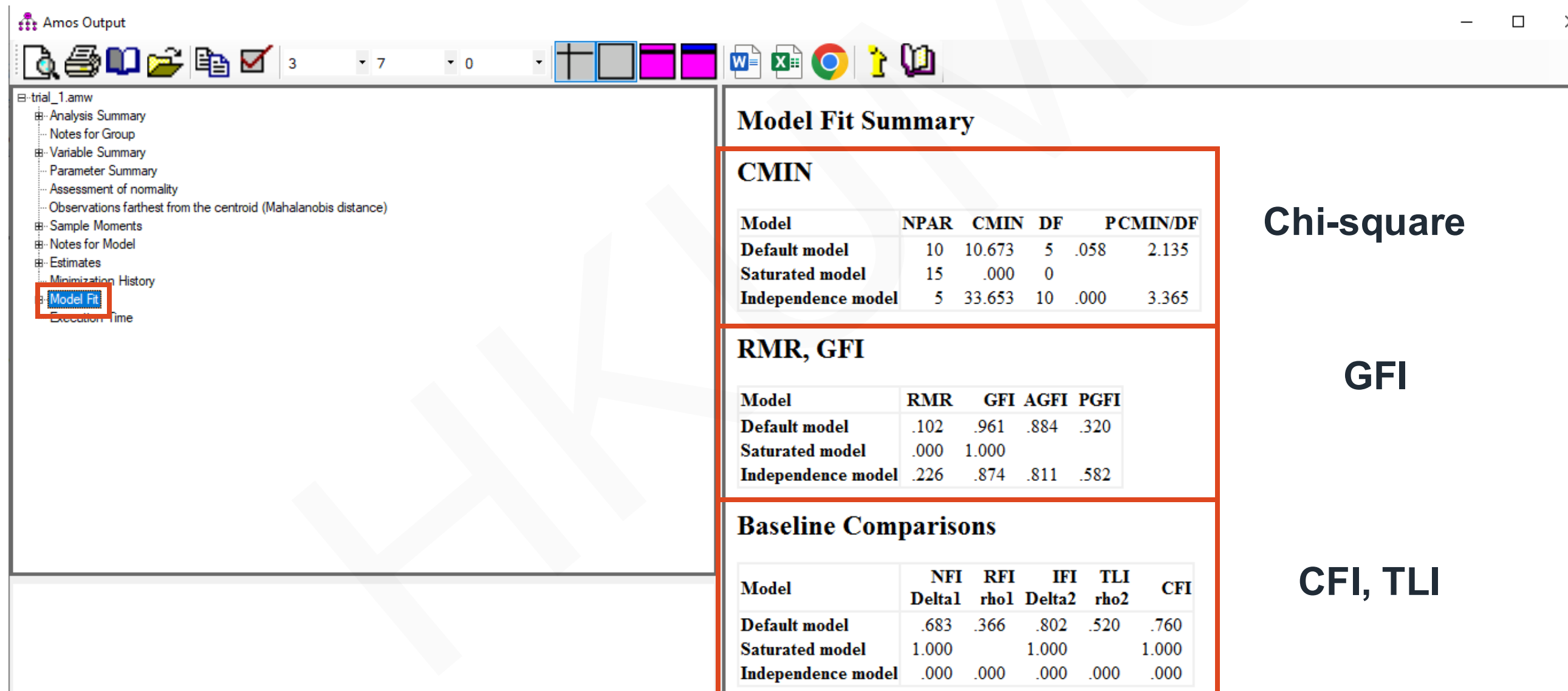
LKS Faculty of Medicine
Bau Institute of Medical &
Health Sciences Education

Menti-meter Activity: CFA Decision in Practice

1. Scan the QR code with your phone.
2. Choose one answer for each question.
3. Let's discuss the answers after each vote.



- Check the Output page by clicking  “**Text Output**” button. Then, click on “**Model Fit**”
- Get the results from the **Default Model**



The screenshot shows the Amos Output window for a file named 'trial_1.amw'. The left sidebar contains a tree view of the output sections, with 'Model Fit' highlighted. The main area displays three tables under the heading 'Model Fit Summary'.

Model Fit Summary

CMIN

Model	NPAR	CMIN	DF	PCMIN/DF
Default model	10	10.673	5	.058
Saturated model	15	.000	0	
Independence model	5	33.653	10	.000

RMR, GFI

Model	RMR	GFI	AGFI	PGFI
Default model	.102	.961	.884	.320
Saturated model	.000	1.000		
Independence model	.226	.874	.811	.582

Baseline Comparisons

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Default model	.683	.366	.802	.520	.760
Saturated model	1.000		1.000		1.000
Independence model	.000	.000	.000	.000	.000

Labels on the right side of the screenshot indicate the following fit indices are present in the tables:

- Chi-square** (corresponds to CMIN)
- GFI** (corresponds to GFI in the RMR, GFI table)
- CFI, TLI** (corresponds to CFI and TLI in the Baseline Comparisons table)

STEP 7 CONT.



- Check the Output page by clicking  **“Text Output”** button. Then, click on **“Model Fit”**
- Get the results from the **Default Model**

Amos Output

trial_1.amw

- Analysis Summary
 - Notes for Group
 - Variable Summary
 - Parameter Summary
 - Assessment of normality
 - Observations farthest from the centroid (Mahalanobis distance)
- Sample Moments
- Notes for Model
- Estimates
 - Minimization history**
 - Execution Time

Independence model 1.000 .000 .000

NCP

Model	NCP	LO 90	HI 90
Default model	5.673	.000	19.167
Saturated model	.000	.000	.000
Independence model	23.653	9.698	45.196

FMIN

Model	FMIN	F0	LO 90	HI 90
Default model	.108	.057	.000	.194
Saturated model	.000	.000	.000	.000
Independence model	.340	.239	.098	.457

RMSEA

Model	RMSEA	LO 90	HI 90	PCLOSE
Default model	.107	.000	.197	.126
Independence model	.155	.099	.214	.002

AIC

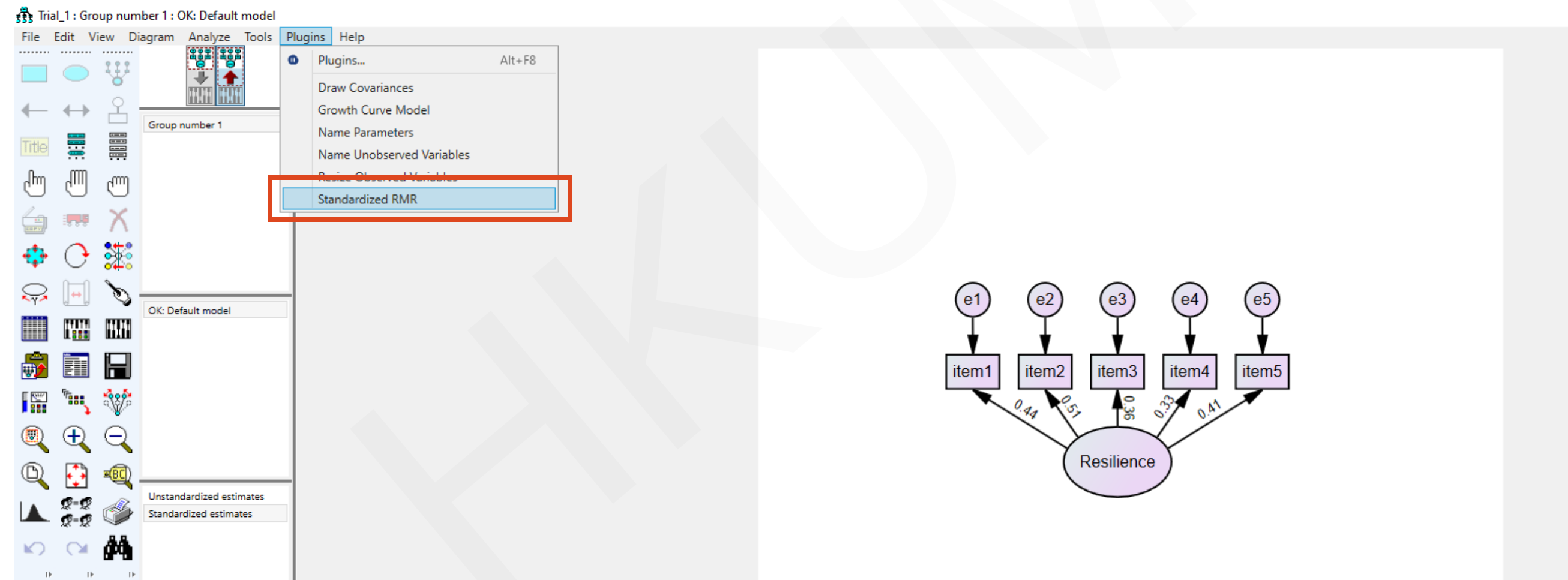
Model	AIC	BCC	BIC	CAIC
Default model	30.673	31.964	56.725	66.725
Saturated model	30.000	31.935	69.078	84.078
Independence model	43.653	44.298	56.679	61.679

RMSEA 90% CI

STEP 7 CONT.

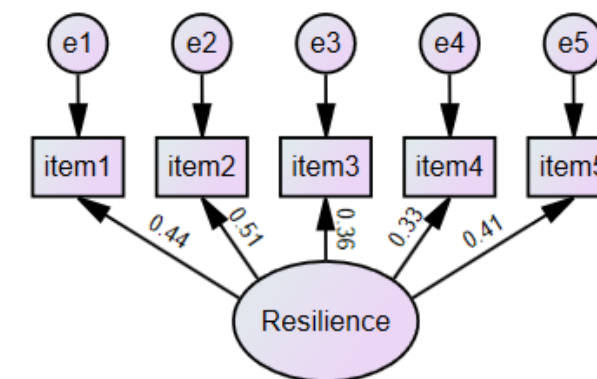
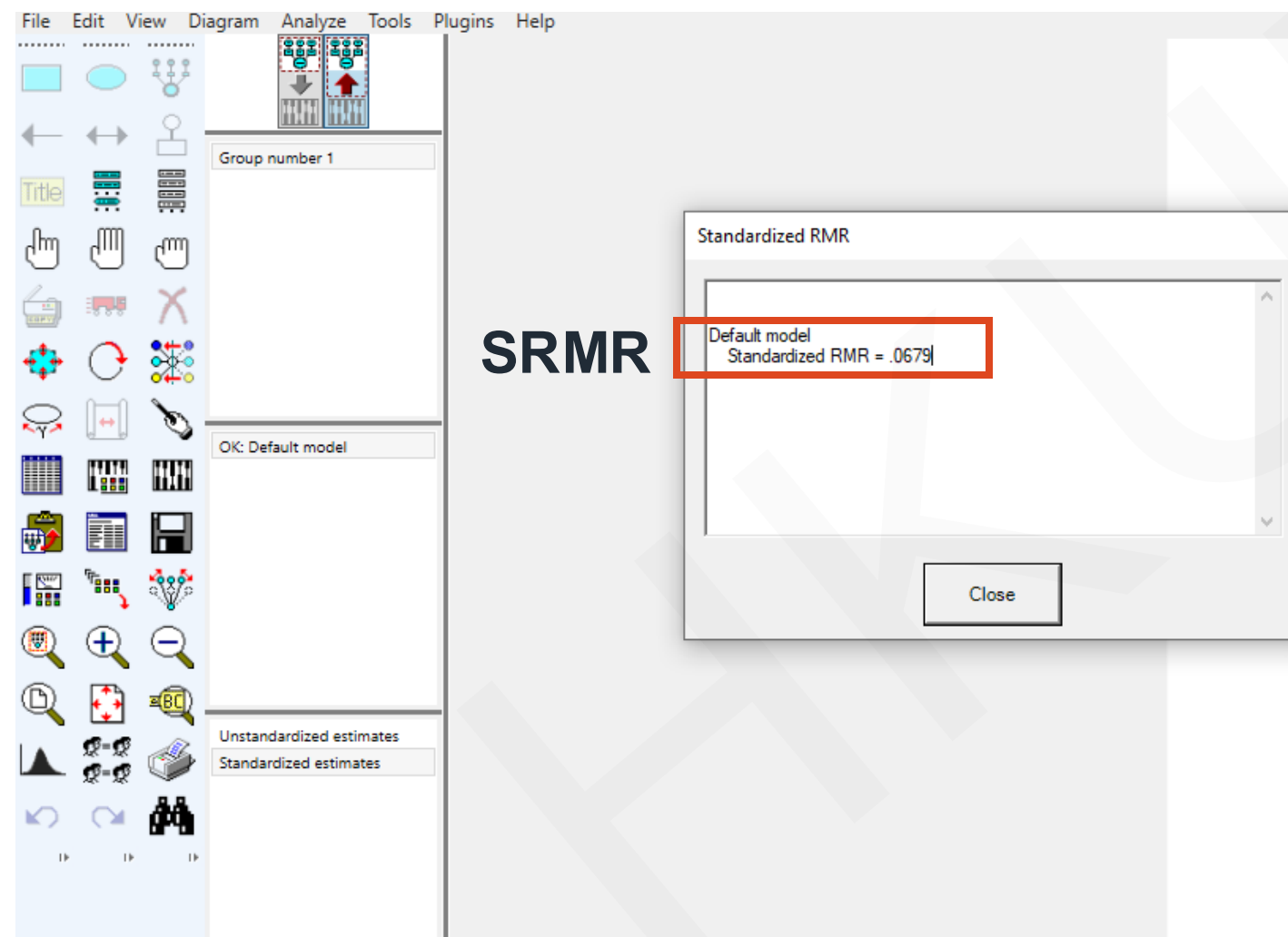


- For SRMR, return to the diagram window. Click Plugins > Standardized RMR, as shown below.



STEP 7 CONT.

- Read the Standardized RMR plugin result as SRMR. The ordinary RMR in Model Fit is not the same statistic.



SRMR and unstandardised RMR differ (Brown, 2015).

STEP 7 CONT.



- Check the Output page by clicking  **“Text Output”** button. Click on **“Estimates”** to check the factor loadings of the items to the latent variable

Amos Output

trial_1.amw

- Analysis Summary
- Notes for Group
- Variable Summary
- Parameter Summary
- Assessment of normality
- Observations farthest from the centroid (Mahalanobis distance)
- Sample Moments
- Notes for Model
- Estimates**
- Minimization History
- Model Fit
- Execution Time

Estimates (Group number 1 - Default model)

Scalar Estimates (Group number 1 - Default model)

Maximum Likelihood Estimates

Regression Weights: (Group number 1 - Default model)

		Estimate	S.E.	C.R.	PLabel
item1	<--- Resilience	1.000			
item2	<--- Resilience	1.060	.493	2.152	.031
item3	<--- Resilience	.841	.432	1.946	.052
item4	<--- Resilience	.812	.442	1.838	.066
item5	<--- Resilience	.974	.473	2.060	.039

Standardized Regression Weights: (Group number 1 - Default model)

		Estimate
item1	<--- Resilience	.442
item2	<--- Resilience	.508
item3	<--- Resilience	.365
item4	<--- Resilience	.328
item5	<--- Resilience	.414

ESTIMATES



- Check if each item loads on its intended factor in the expected direction. Check reverse coding if a sign is unexpected.
- If standardised loadings is below .500. Consider item wording, purpose and the other results before deciding whether to keep an item.

Regression Weights: (Group number 1 - Default model)

		Estimate	S.E.	C.R.	PI	label
@52	<--- Parent_support	1.000				
@47	<--- Parent_support	.902	.038	23.696	***	
@37	<--- Parent_support	1.079	.044	24.597	***	
@26	<--- Parent_support	.842	.038	22.405	***	
@15	<--- Parent_support	.898	.038	23.494	***	
@39	<--- Peer_support	1.000				
@28	<--- Peer_support	1.177	.040	29.741	***	
@17	<--- Peer_support	.952	.034	28.236	***	
@48	<--- Teacher_support	1.000				
@38	<--- Teacher_support	1.184	.062	19.192	***	
@27	<--- Teacher_support	1.141	.057	20.178	***	
@16	<--- Teacher_support	1.487	.065	22.920	***	
@4	<--- Teacher_support	1.202	.057	21.266	***	
@8a	<--- Parent_support	.953	.042	22.672	***	
@5	<--- Peer_support	.908	.033	27.752	***	

Standardized Regression Weights: (Group number 1 - Default model)

	Estimate
@52 <--- Parent_support	.686
@47 <--- Parent_support	.674
@37 <--- Parent_support	.704
@26 <--- Parent_support	.631
@15 <--- Parent_support	.667
@39 <--- Peer_support	.771
@28 <--- Peer_support	.782
@17 <--- Peer_support	.736
@48 <--- Teacher_support	.599
@38 <--- Teacher_support	.598
@27 <--- Teacher_support	.641
@16 <--- Teacher_support	.795
@4 <--- Teacher_support	.693
@8a <--- Parent_support	.640
@5 <--- Peer_support	.722



ACTIVITY 1

- 1. Write the corresponding values for each of the fit indices on the blanks provided.
- 2. Write the values needed on the Table.
 - Refer to your CFA results following what you learned from the tutorial.
- 3. Screenshot the CFA measurement model and paste it on the Figure page.

TASK 1

3. Results

3.1 Sample characterization. Describe concisely the demographic details of your full-scale administration participants (e.g., mean age, gender, discipline, and year-level distribution, etc.). Indicate here as well the descriptive results of the participants based on the aggregate scoring of your new scale.

3.2 Descriptive and bivariate correlations. You can get the format and pattern of reporting such results from previous studies.

3.3 Confirmatory factor analysis

Based on the CFA results, the fit indices indicate an acceptable fit between the data and the hypothesized model. The three-factor structure of the Facilitating Conditions Questionnaire was supported by the data: GFI = __, CFI = __, TLI = __, RMSEA = __ (CI 90% = __ – __), and SRMR = __. Overall, these fit indices support the validity of the three-factor Facilitating Conditions Questionnaire among a sample of medical students in Hong Kong.

TASK 2 (add the acceptable fit)

Table 2. Fit indices of the three-factor FCQ among medical students in Hong Kong (n = 1669)

Model	χ^2	<i>p</i>	χ^2/df	GFI	CFI	TLI	RMSEA	90% CI	SRMR
Hypothesized model									

TASK 3

Fig. 1. The three-factor Facilitating Conditions Questionnaire

(Insert Figure screenshot here)

POOR FIT: CHECKS AND JUSTIFIED CHANGES

1. Check the data and diagram

Check item coding, the attached dataset file and the item-to-factor links.

2. Inspect where the model struggles

In Text Output, read Estimates > Standardized Regression Weights. Review weak loadings and the item wording together.

3. Request diagnostic output

View > Analysis Properties > Output: tick Modification indices. Run again, then open these sections in Text Output.

4. Make a change only with a clear reason

For example, similarly worded items may share extra error. A large modification index alone does not justify linking their errors or deleting an item.

5. Check the revised model

Save a copy, make one justified change and rerun. Record the reason and compare fit. Check the revised model in another sample when possible.

Brown, (2015); MacCallum et al., (1992).



THANK YOU!

For further queries, please email: **Mr Samson Shen (samson66@hku.hk)**