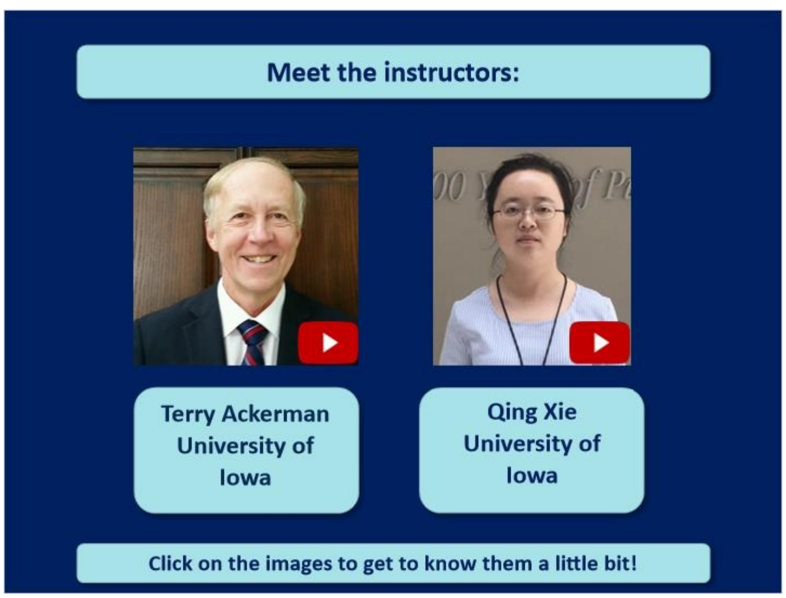
MIRT Graphics

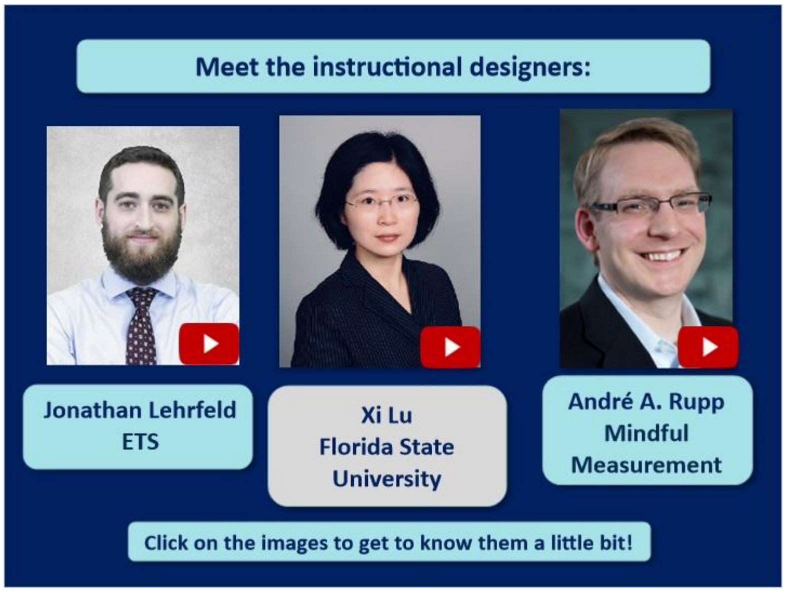
1. Module Overview

1.1 Module Cover (START)

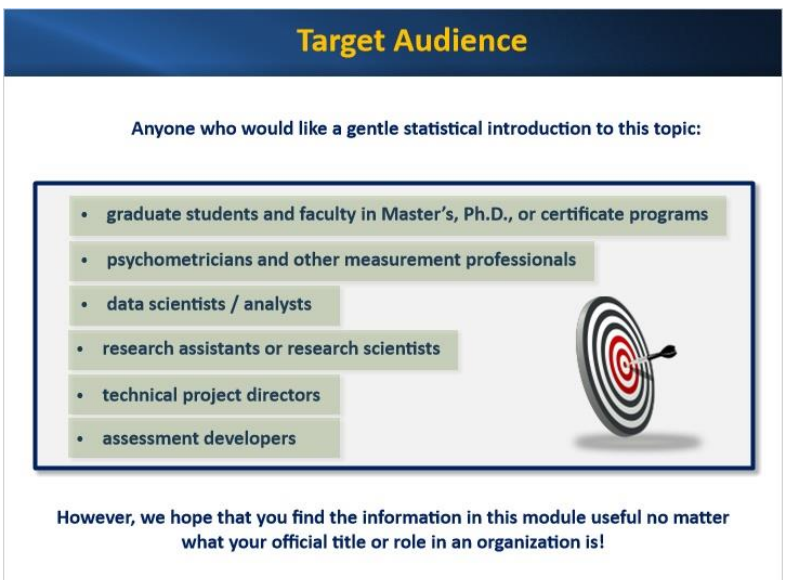
1.2 Instructors



1.3 Designers

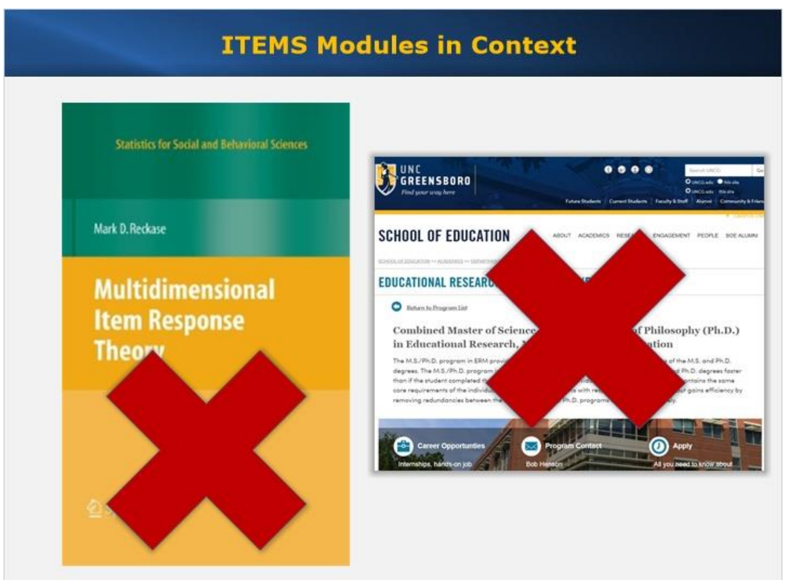


1.4 Target Audience

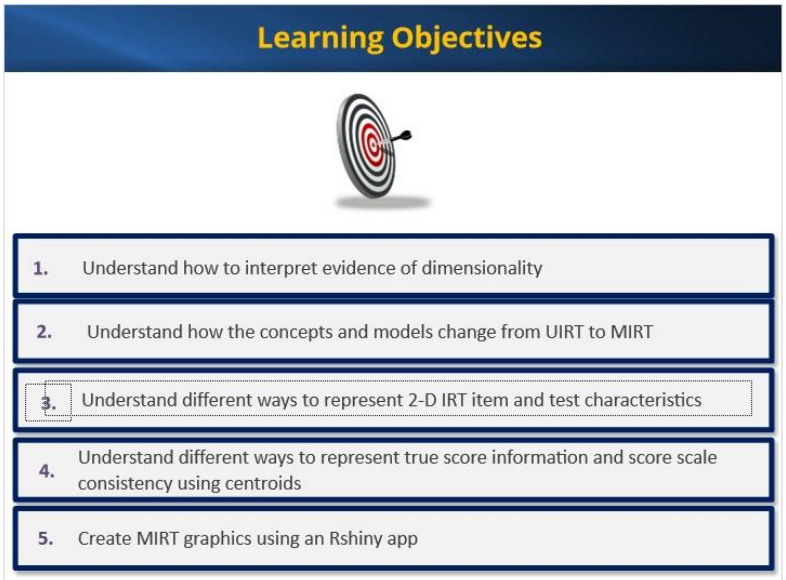


1.5 Expecations (I)

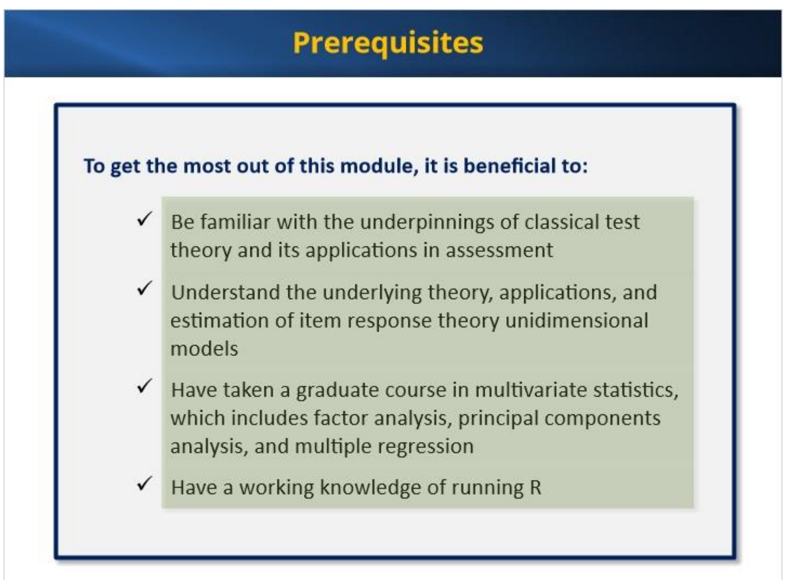
1.6 Expectations (II)



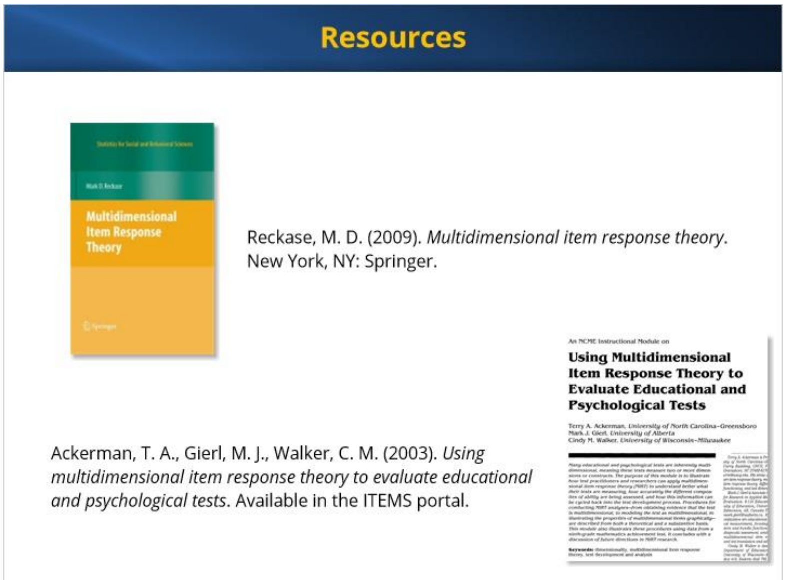
1.7 Learning Objectives



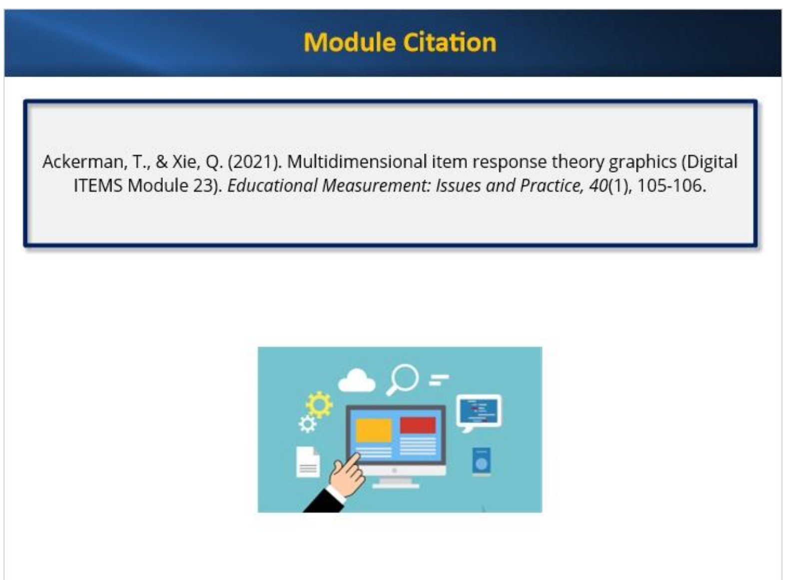
1.8 Prerequisites



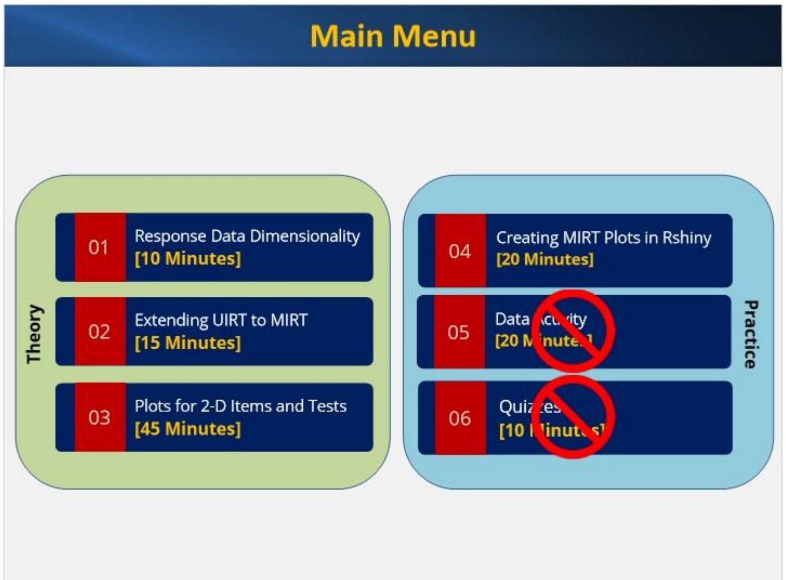
1.9 Resources



1.10 Module Citation



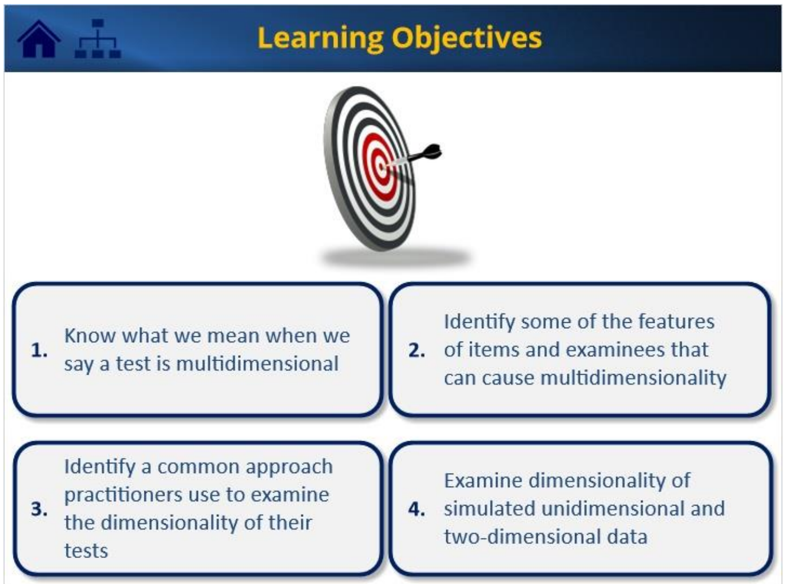
1.11 Main Menu



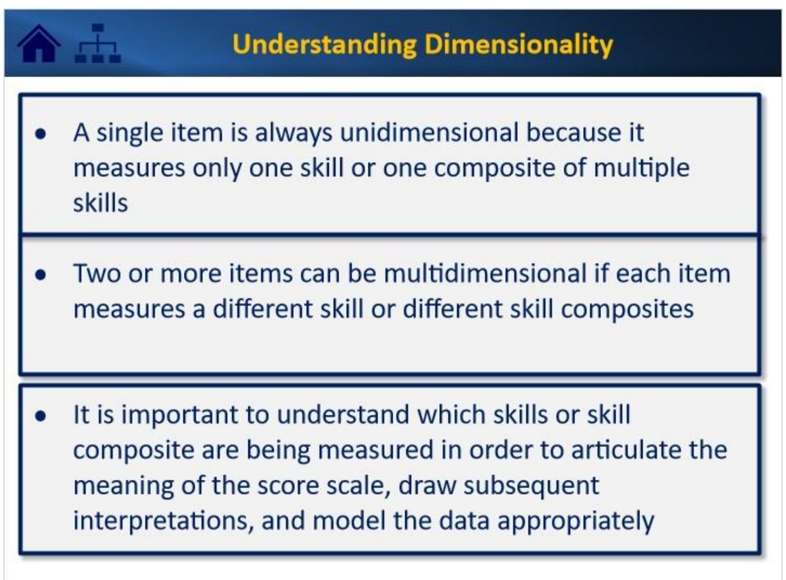
2. Response Data Dimensionality

2.1 Cover: Response Data Dimensionality

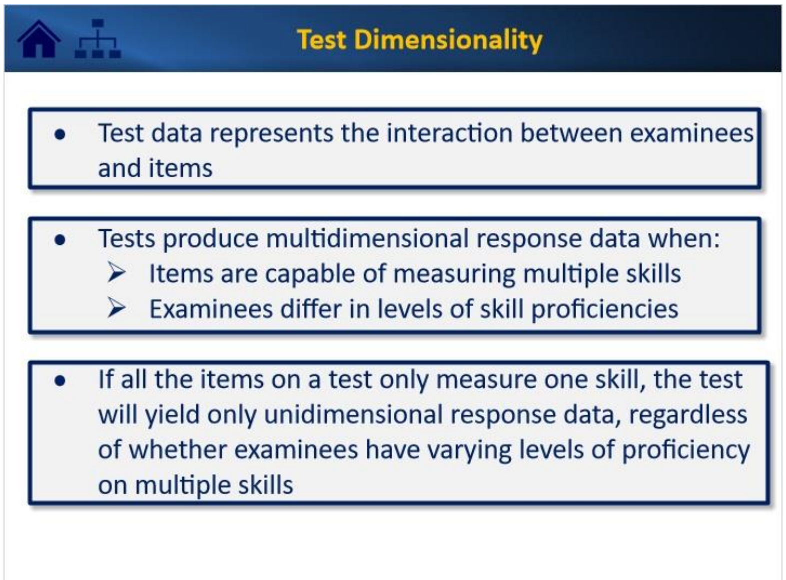
2.2 Learning Objectives: Response Data Dimensionality



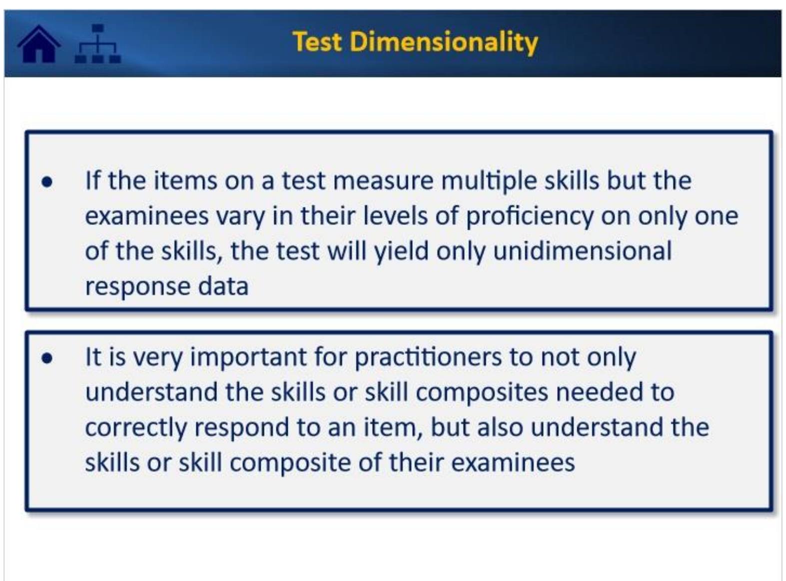
2.3 Understanding Dimensionality



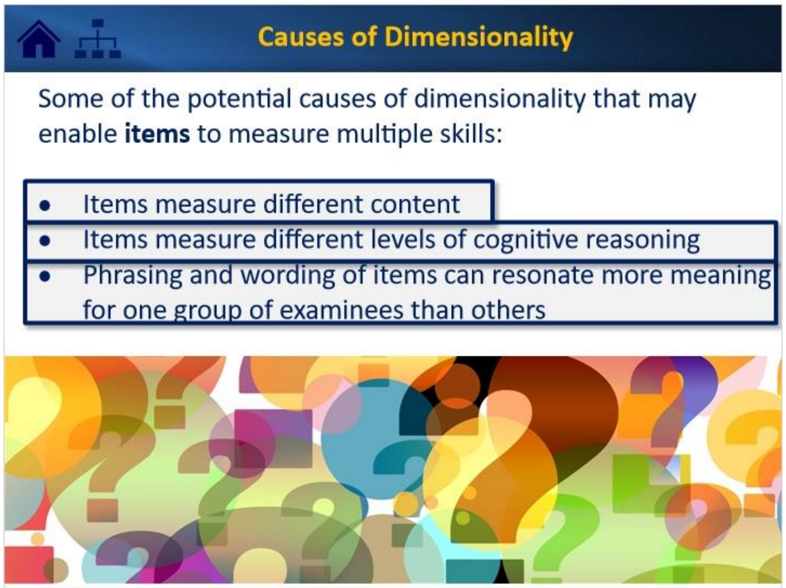
2.4 Test Dimensionality (I)



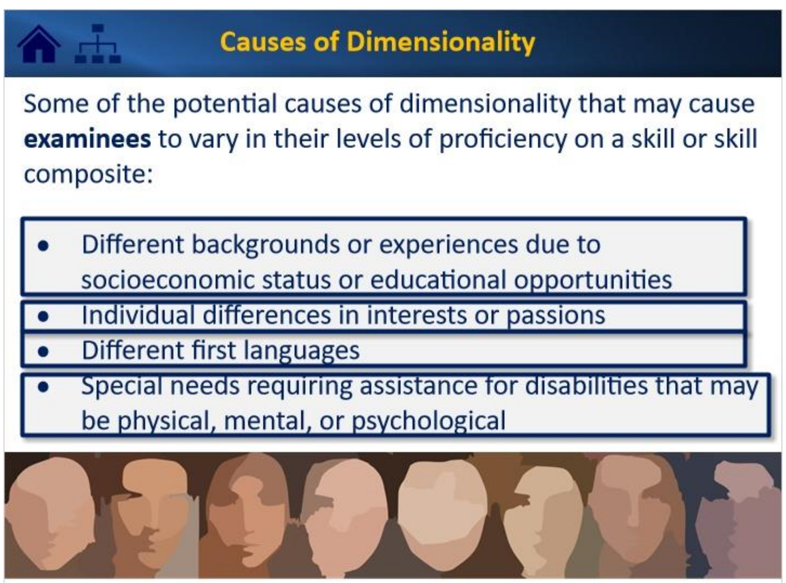
2.5 Dimensionality (II)



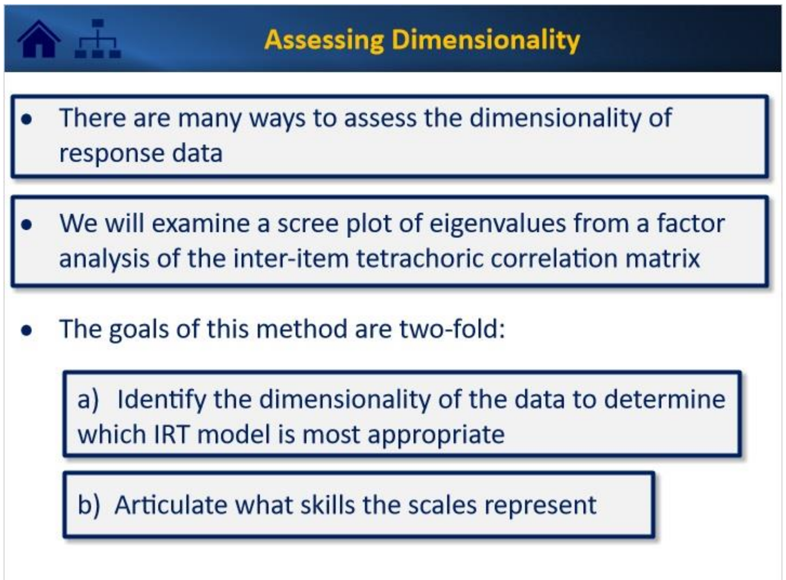
2.6 Causes of Dimensionality (I)



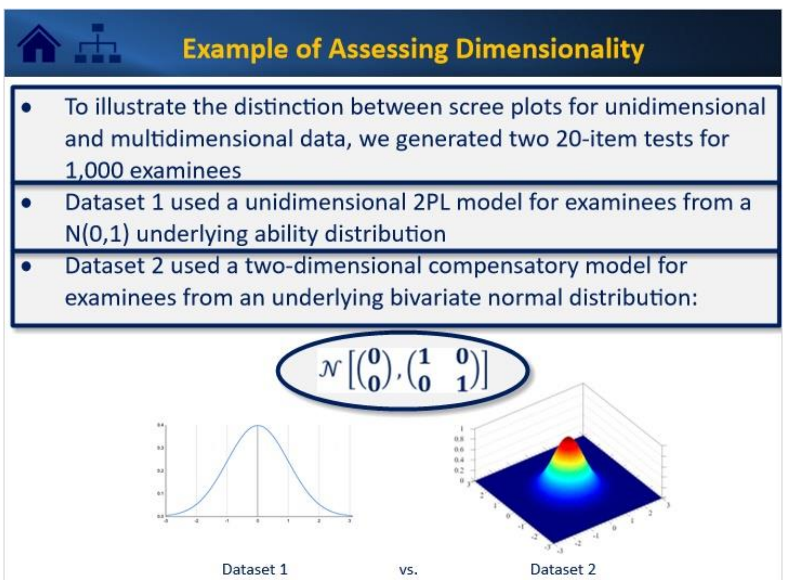
2.7 Causes of Dimensionality (II)



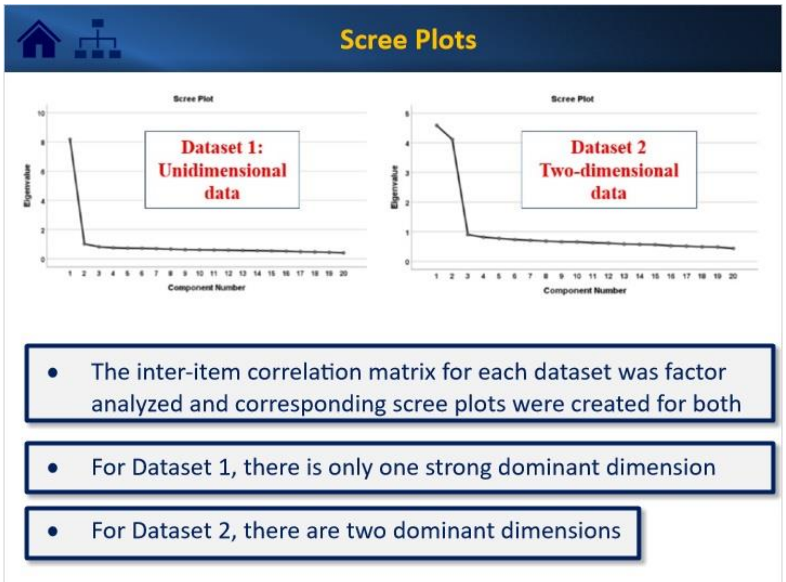
2.8 Assessing Dimensionality



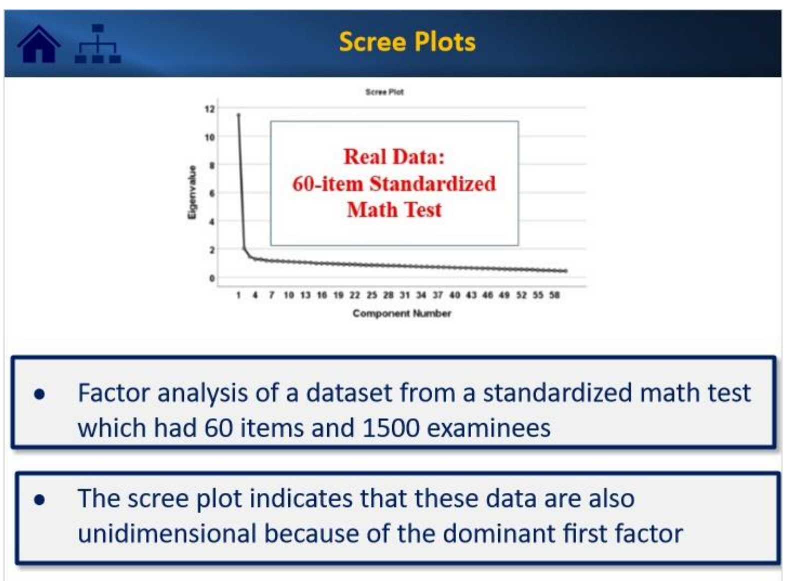
2.9 Example of Assessing Dimensionality



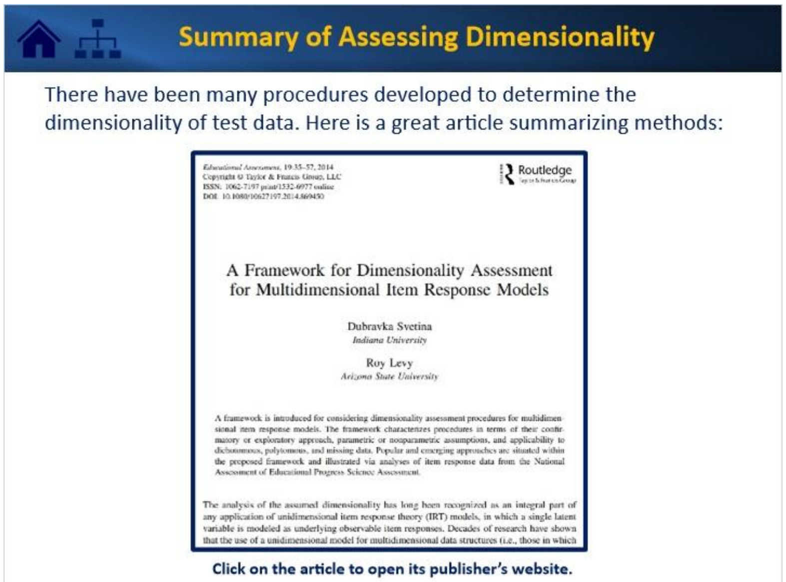
2.10 Scree Plots (I)



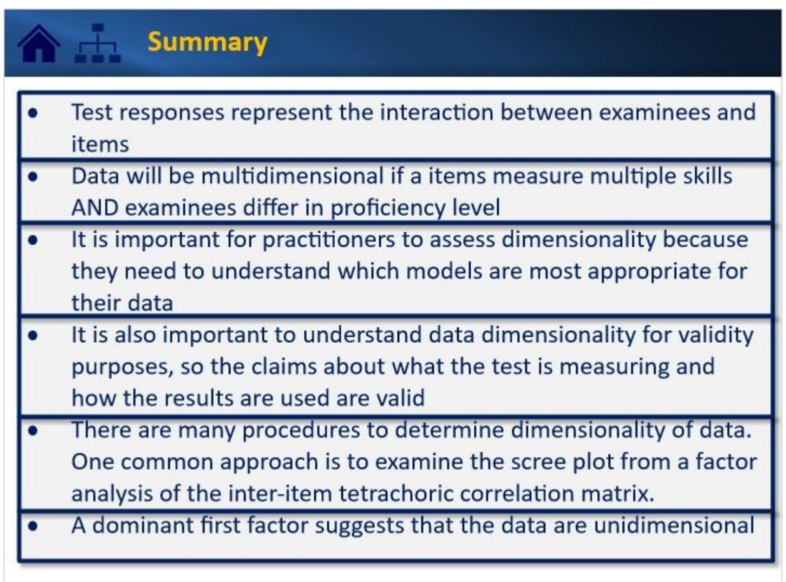
2.11 Scree Plots (II)



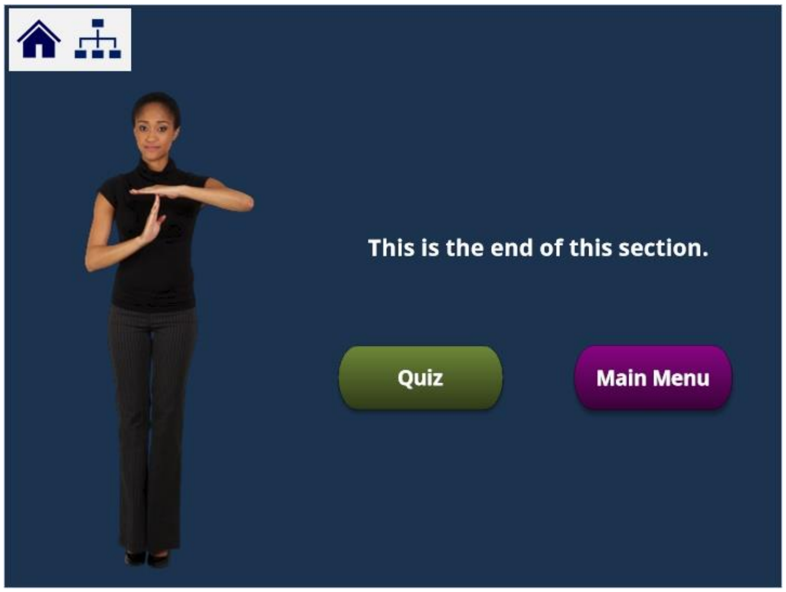
2.12 Summary of Assessing Dimensionality



2.13 Summary: Response Data Dimensionality

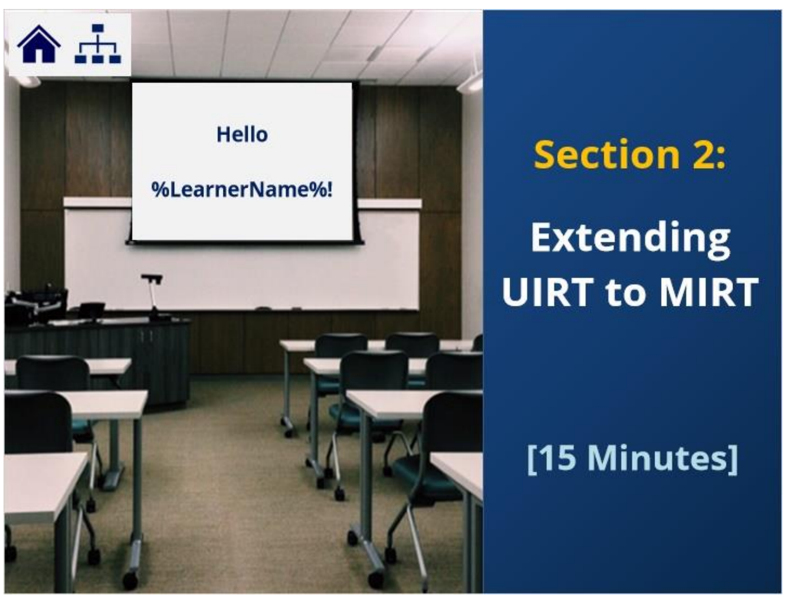


2.14 Bookend: Response Data Dimensionality

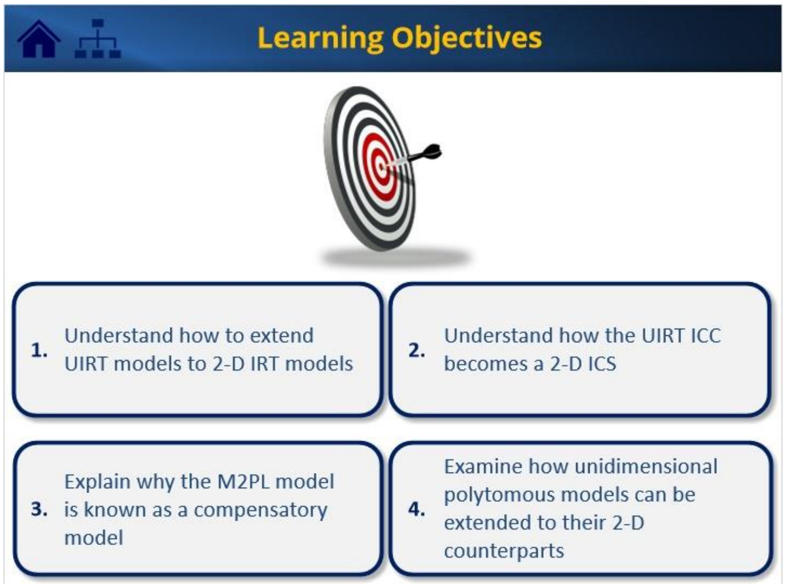


3. Extending UIRT to MIRT

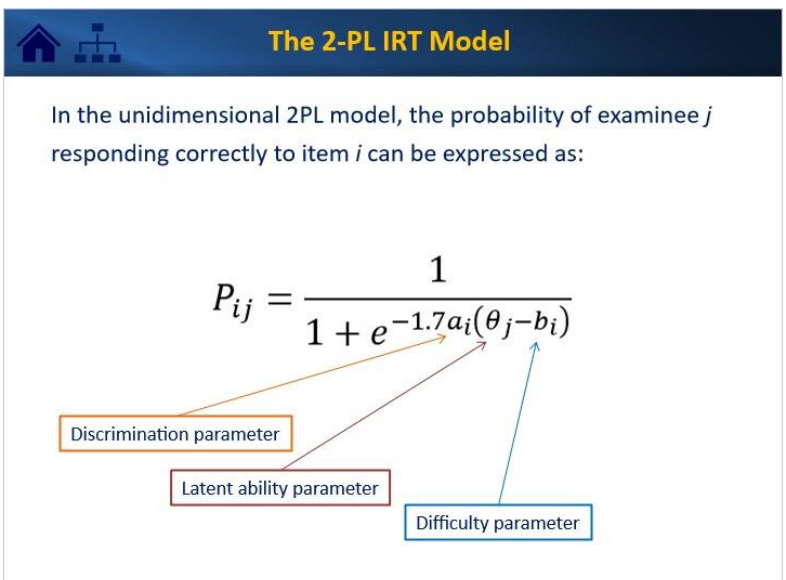
3.1 Cover: Extending UIRT to MIRT



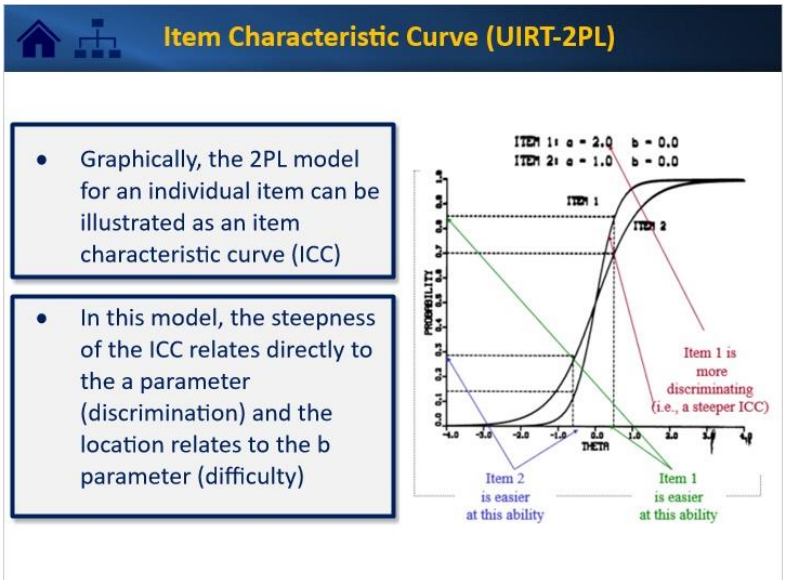
3.2 Learning Objectives: Extending UIRT to MIRT



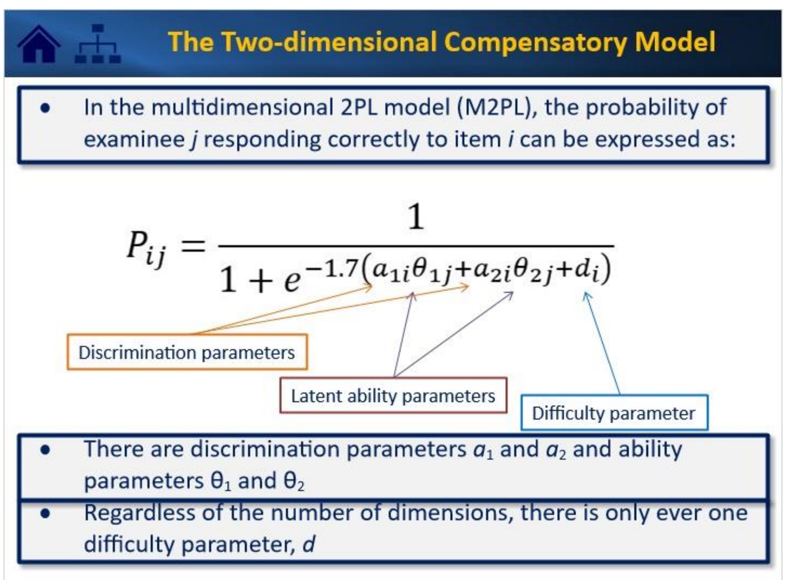
3.3 The 2PL IRT Model



3.4 Item Characteristic Curves for UIRT 2PL



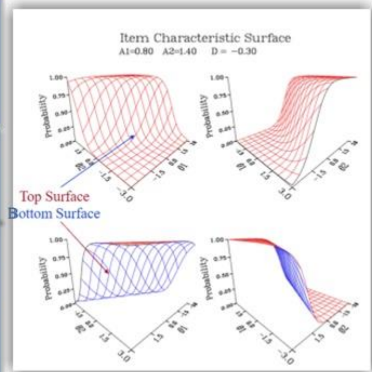
3.5 The 2-Dimensional Compensatory Model



3.6 2-D Compensatory Item Surface

2-D Compensatory Item Surface

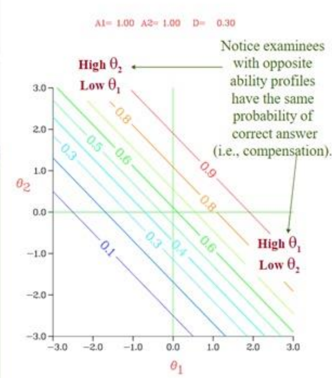
- Under the 2-D compensatory model, items can be illustrated with item characteristic surfaces (ICSs)
- The steepness of the ICS relates directly to the a parameters
- The relative sizes of the *a*s indicate which composite of θ_1 and θ_2 is being best measured. If $a_1 = a_2$, θ_1 and θ_2 are being measured equally well. If $a_1 > a_2$, θ_1 is being given greater emphasis, and if $a_1 < a_2$, θ_2 is being given greater emphasis.



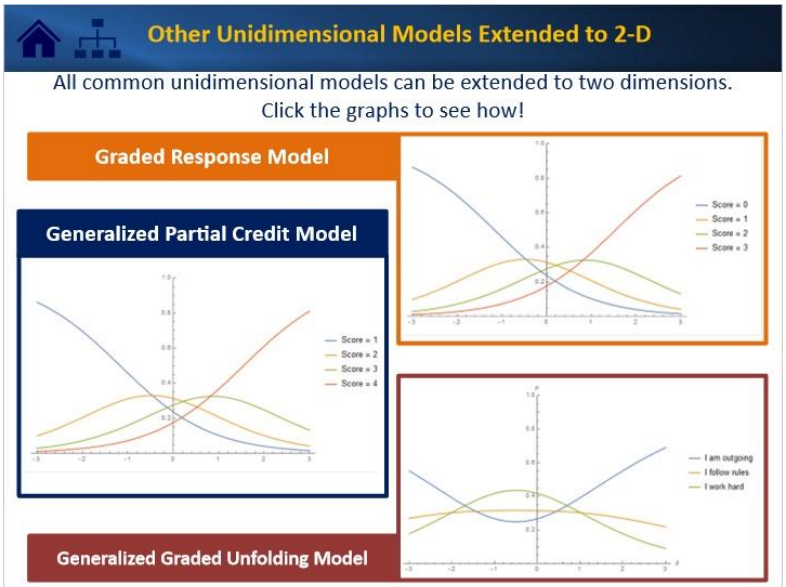
3.7 Compensatory Surface Contour

Compensatory Surface Contour

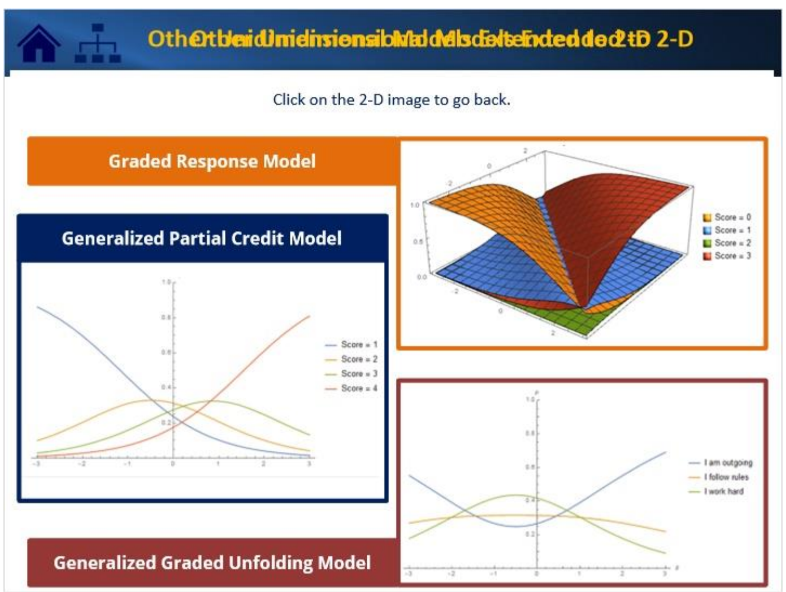
- Equiprobability contours are always parallel for the compensatory model
- Every (θ1,θ2) combination on the same contour has the same response probability
- When $a_1 = a_2$, compensation between abilities is optimal: examinees who are high on θ_1 but low on θ_2 have the same probability of answering correctly as an examinee with the opposite profile because being high on one ability compensates for being low on the other.



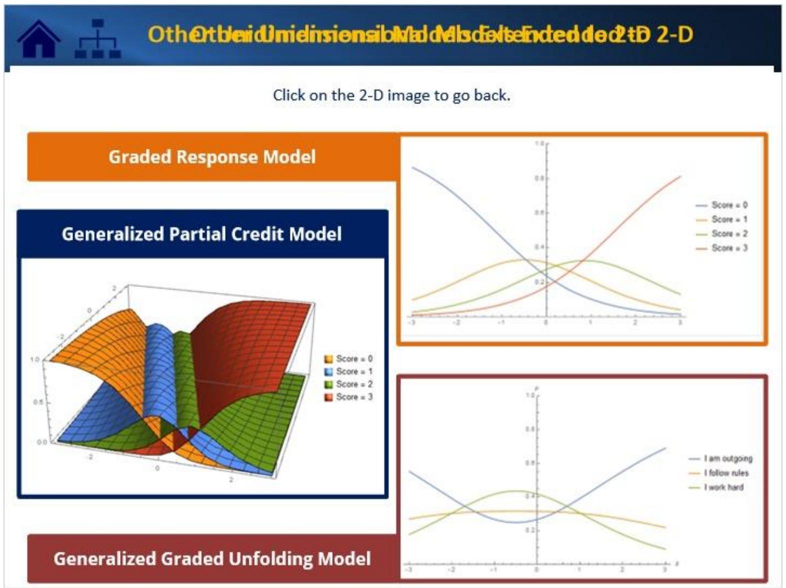
3.8 Other Unidimensional Models Extended to 2D



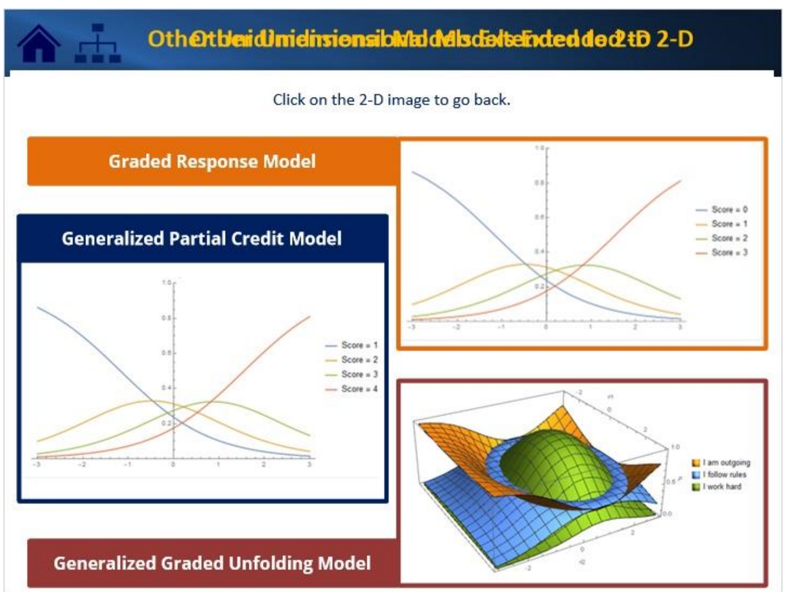
2DGRM (Slide Layer)



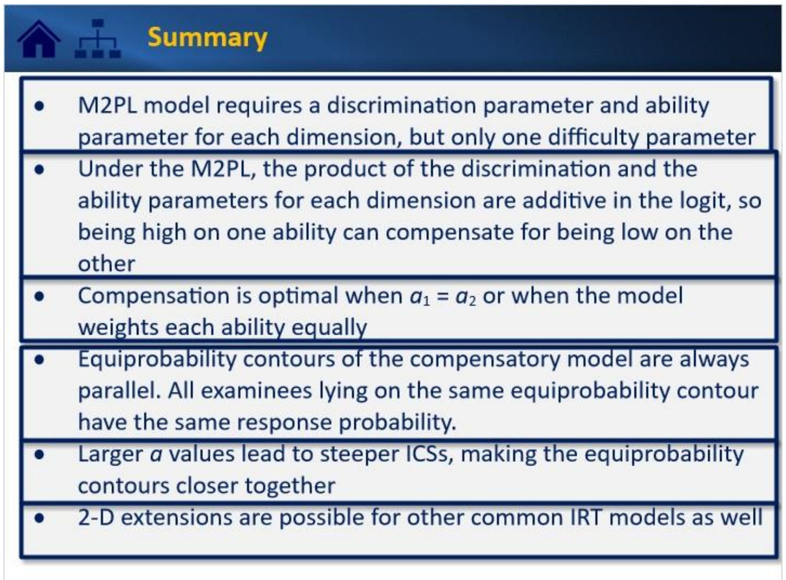
2DGPCM (Slide Layer)



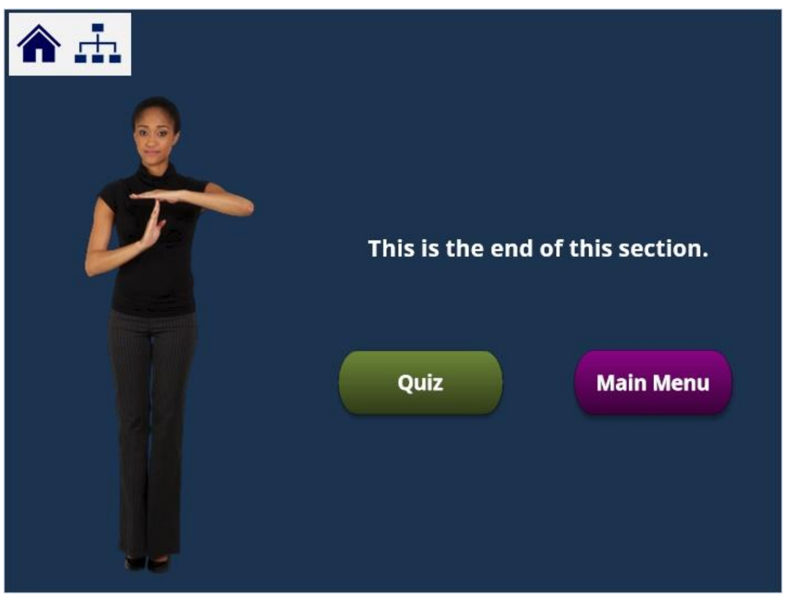
2DGGUM (Slide Layer)



3.9 Summary: UIRT and MIRT Concepts

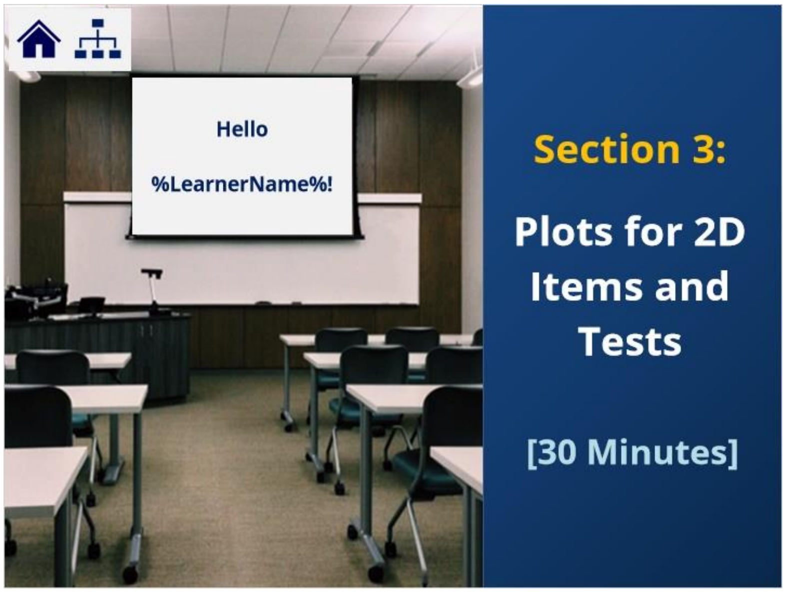


3.10 Bookend: Extending UIRT to MIRT

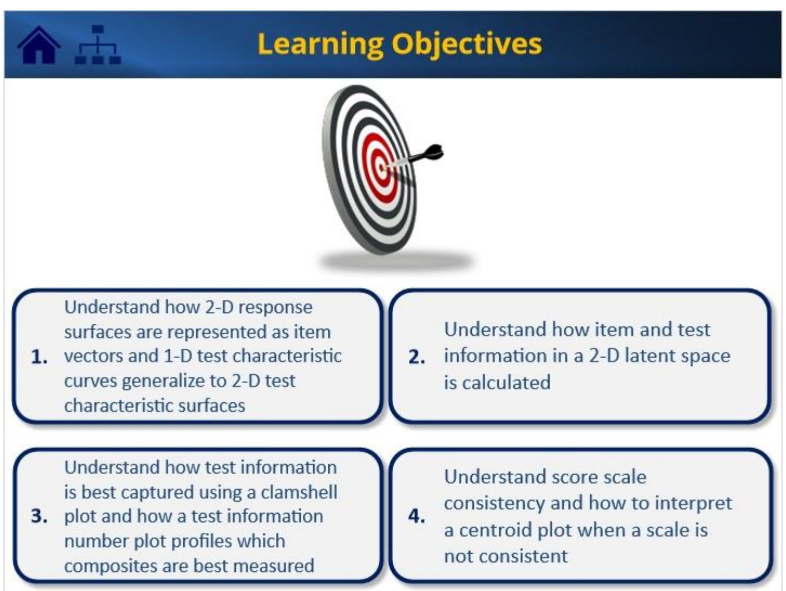


4. Plots for 2D Items and Tests

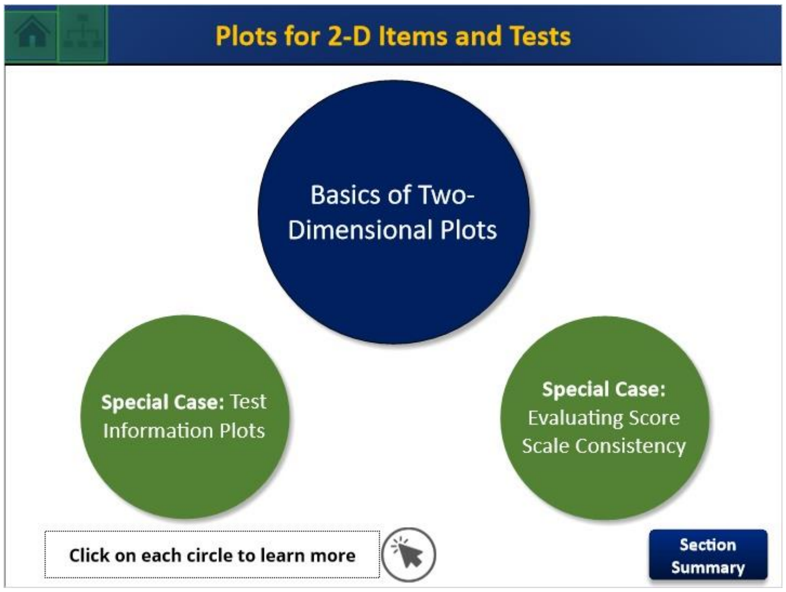
4.1 Cover: Plots for 2D Items and Tests



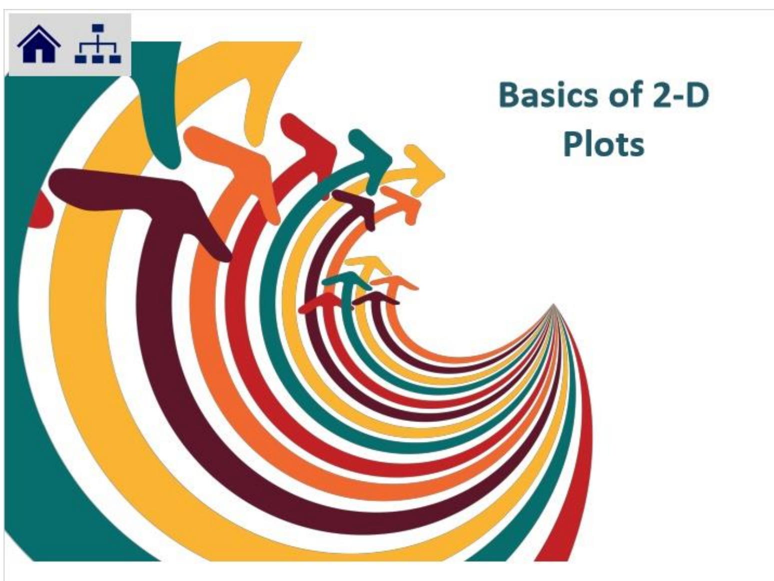
4.2 Learning Objectives: Plots for 2D Items and Tests



4.3 Topic Selection



4.4 Bookmark: Basics of 2-D Plots



4.5 Item Vectors (I)

Item Vectors

- Plotting multiple ICSs can be very cumbersome
- Perhaps the best representation of 2-D tests is to represent each item as a vector in the latent ability plane

- Guidelines for process:
  1. All vectors lie on lines that pass through the origin
  2. Vectors can lie only in the first and third quadrants because a parameters are constrained to be positive
  3. Vectors representing easy items lie in the third quadrant; vectors representing difficult items lie in the first quadrant

- To create a vector, you need to know the length, the origin, and the angle with the θ1-axis

4.6 Item Vectors (II)

Item Vectors

- The length of the vector indicates how discriminating the item is. This value is called MDISC.

$$\text{MDISC} = \sqrt{(a_1^2 + a_2^2)}$$

- The tail of the vector lies on the p = .50 equiprobability contour. The signed distance from the origin to this contour is denoted as MDIFF

$$\text{MDIFF} = \frac{-d}{\text{MDISC}}$$

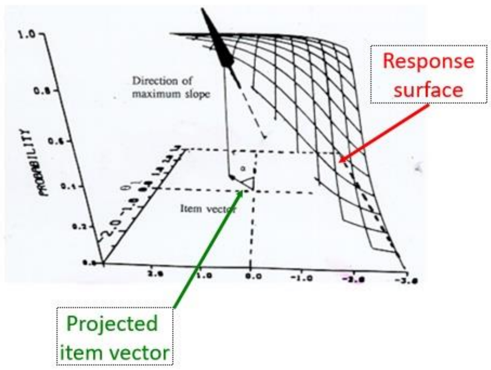
- The angular direction indicates the composite of ability that the item is best measuring

$$\alpha = \cos^{-1}\left(\frac{a_1}{\text{MDISC}}\right)$$

4.7 Item Vectors (III)

Item Vectors

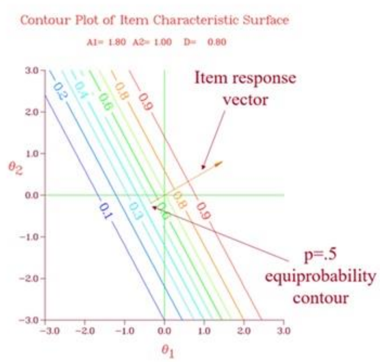
Vectors are actually projections of the direction of maximum discrimination or slope onto the latent ability plane



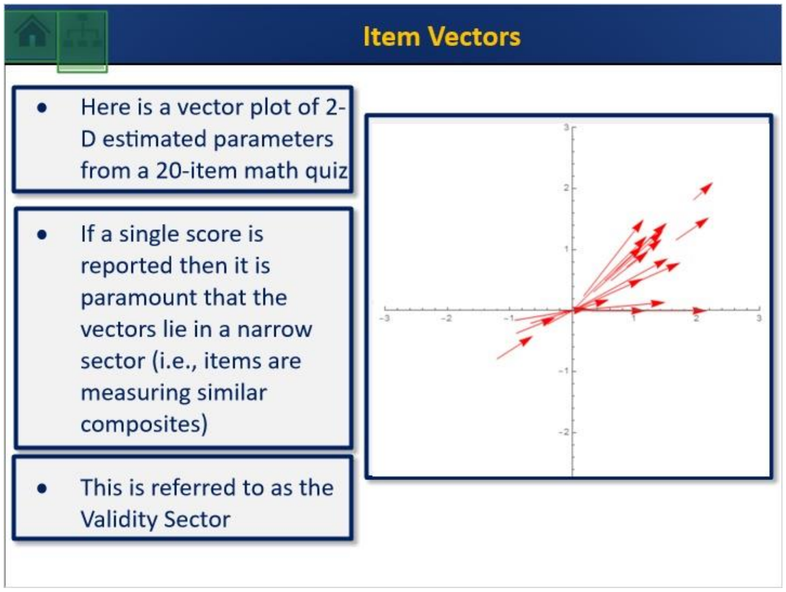
4.8 Item Vectors (III)

Item Vectors

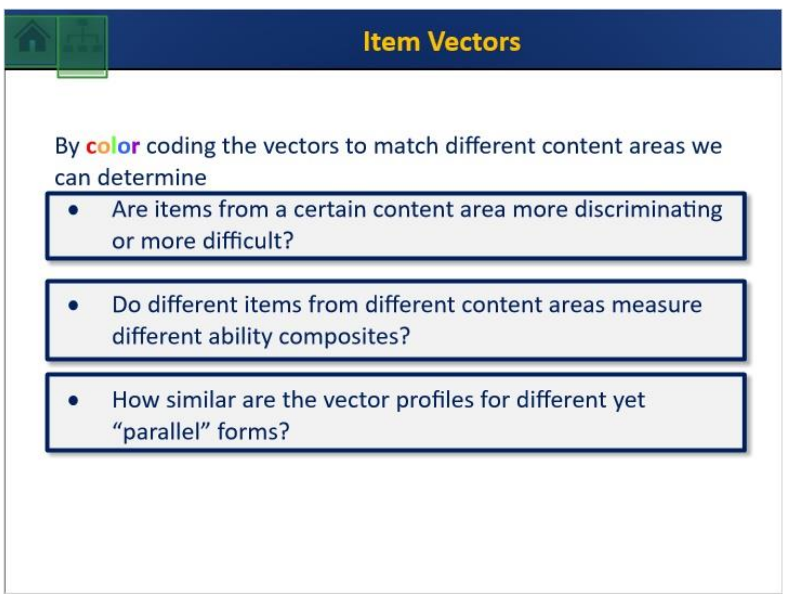
In the figure below, an item vector is plotted onto a contour plot of the item's surface. Note that the vector is orthogonal to the p = .5 contour. The closer together the contours, the larger the MDISC value and the longer the vector.



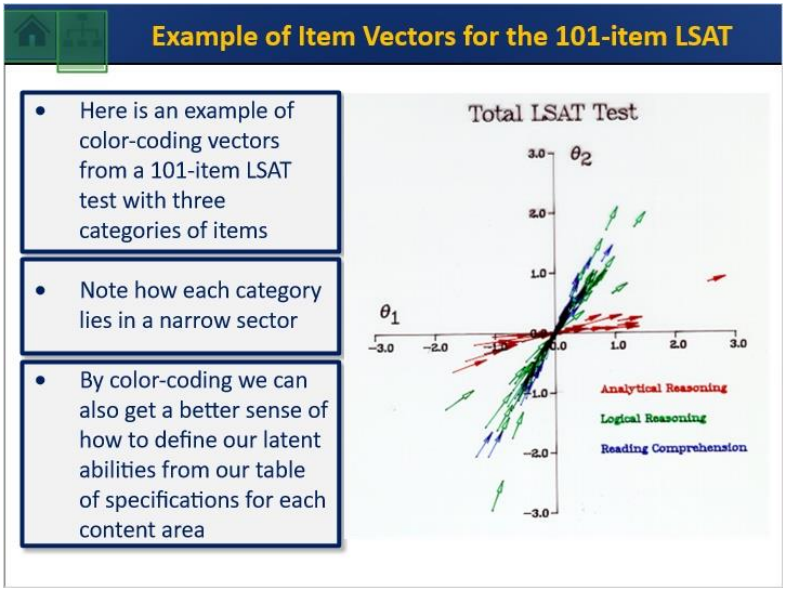
4.9 Item Vectors (IV)



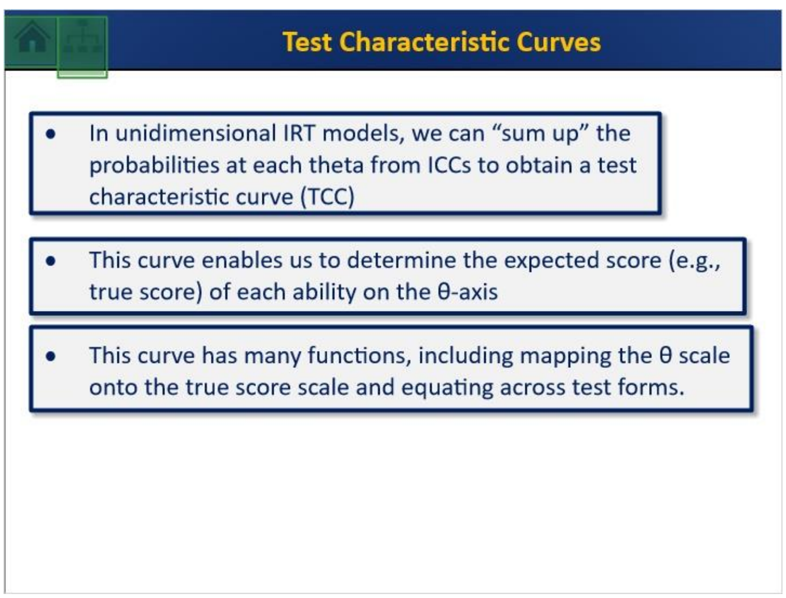
4.10 Item Vectors (V)



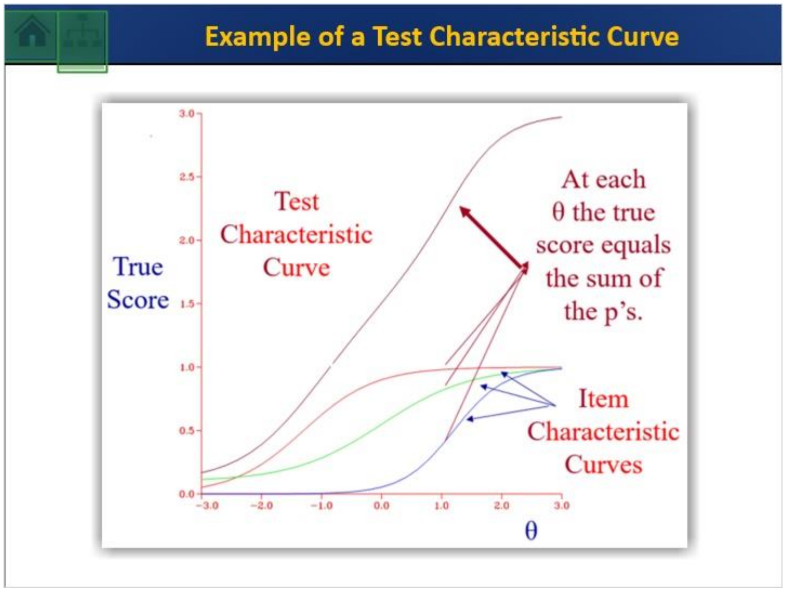
4.11 Example of Item Vectors for the 101-Item LSAT



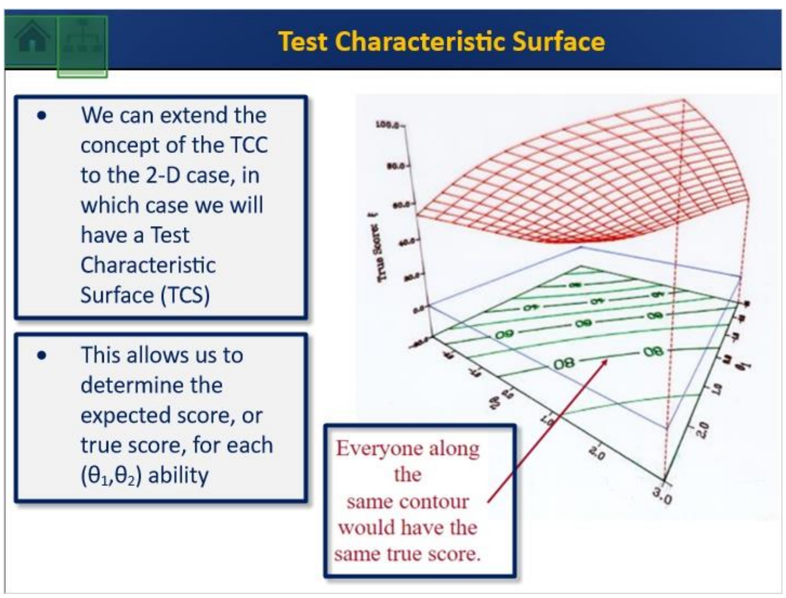
4.12 Test Characteristic Curves



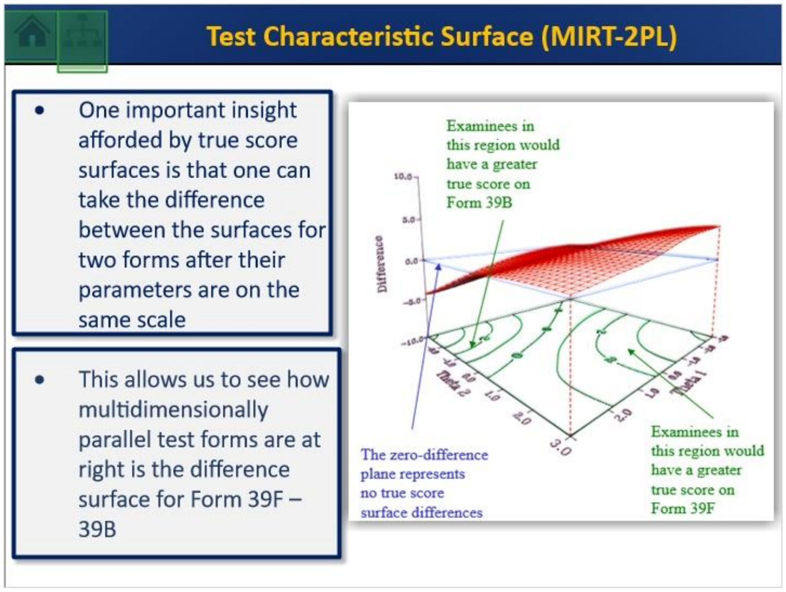
4.13 Example of a Test Characteristic Curve



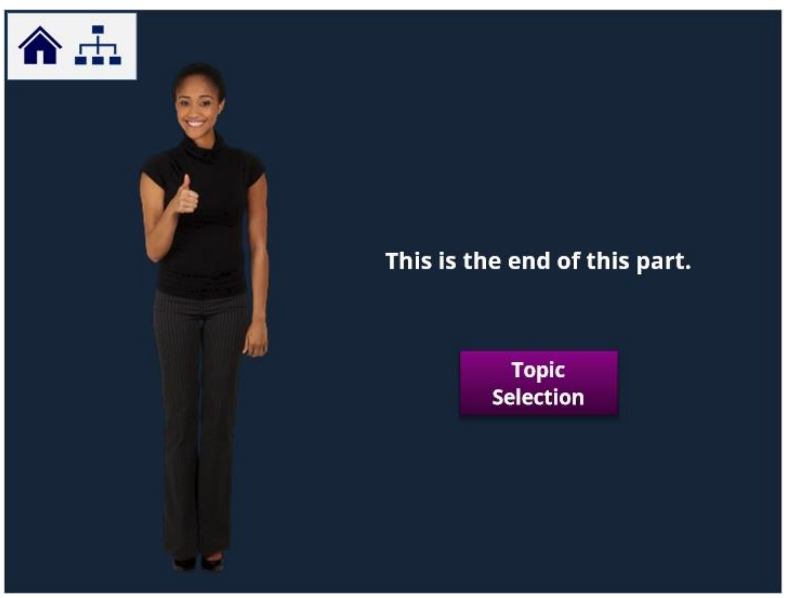
4.14 Test Characteristic Surface



4.15 Test Characteristic Surface (II)

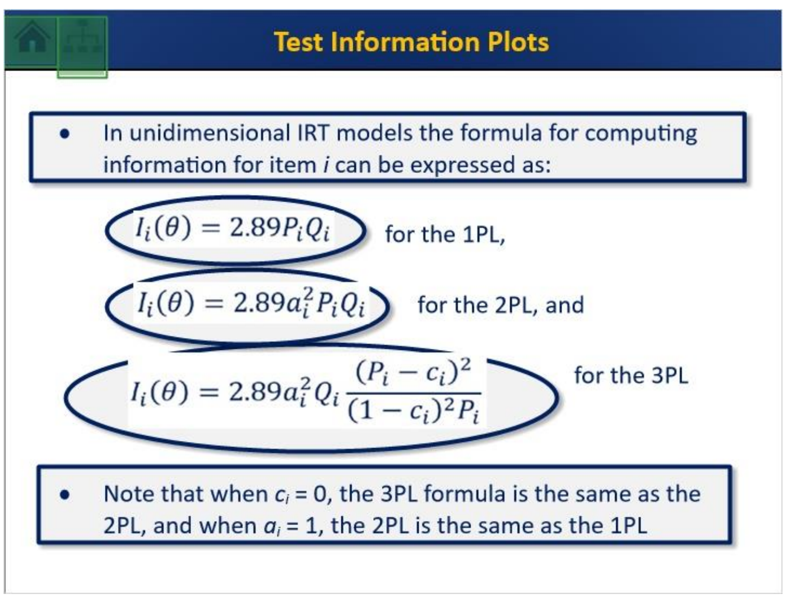


4.16 Bookend: Basics of 2-D Plots

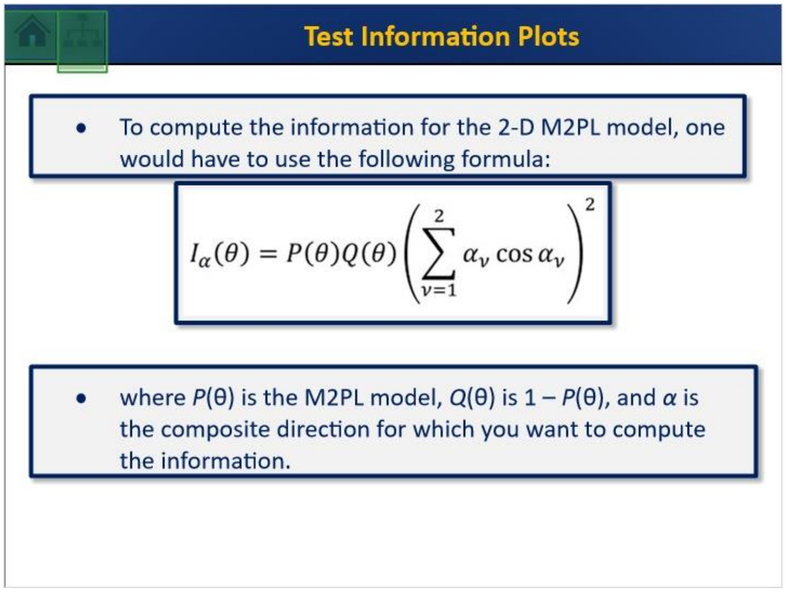


4.17 Bookmark: Test Information Plots

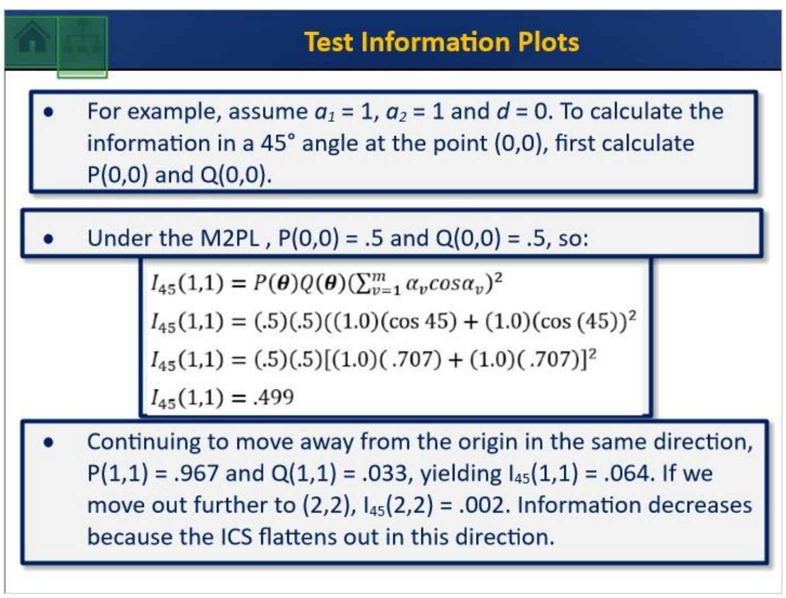
4.18 Test Information Plots (I)



4.19 Test Information Plots (II)



4.20 Test Information Plots (III)



4.21 Test Information Plots (IV)

Test Information Plots

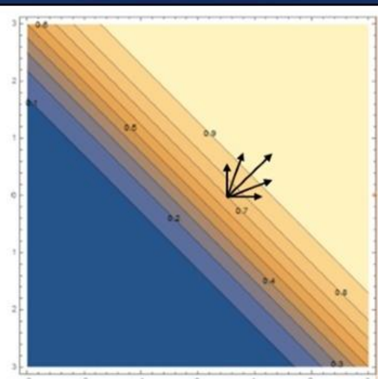
- Assume we are still working with the same item but now want to calculate $I_{30}(0,0)$:

$$I_{30}(0,0) = P(\boldsymbol{\theta})Q(\boldsymbol{\theta})(\sum_{v=1}^{m} \alpha_v cos\alpha_v)^2$$
$$I_{30}(0,0) = (.5)(.5)((1.0)(\cos 30) + (1.0)(\cos 60))^2$$
$$I_{30}(0,0) = (.5)(.5)[(1.0)(.866) + (1.0)(.5)]^2$$
$$I_{30}(0,0) = .466$$

- Further, $I_0(0,0) = .25$. The angle of maximum information when $a_1 = a_2$ is at 45°, or orthogonal to the equiprobability contours. As we move away from this direction, the surface is not as steep, the item is not as discriminating, and the information decreases.

4.22 Test Information Plots

Test Information Plots



The previous calculations are illustrated with information vectors at 0°, 30°, 45°, 60°, and 90°. The lengths of the vectors indicate the amount of information. The longest vector is at 45° and is orthogonal to the equiprobability contours.

4.23 Clamshell Plots (I)

Clamshell Plots

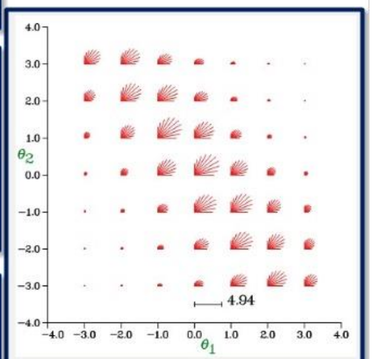
Reckase and McKinley (1991) show a way to illustrate the amount of information for the M2PL model using a "clamshell" plot. To create this plot:

1. The amount of information is computed as 49 uniformly spaced points on a 7x7 grid on the (θ_1,θ_2) plane
2. At each point, the amount of information the test provides is computed for ten different directions (or ability composites) from 0 to 90 degrees in 10-degree increments
3. The resulting ten vectors at each ability point resemble a clamshell

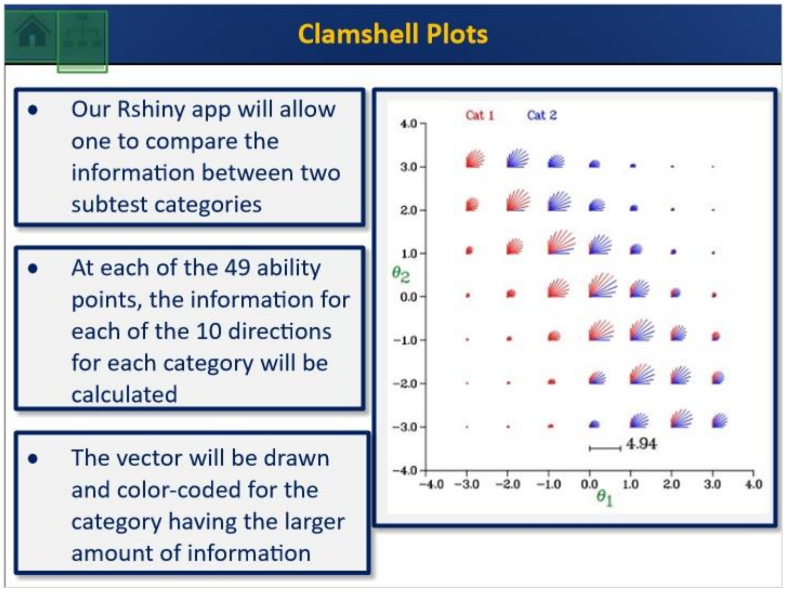
4.24 Clamshell Plots (II)

Clamshell Plots

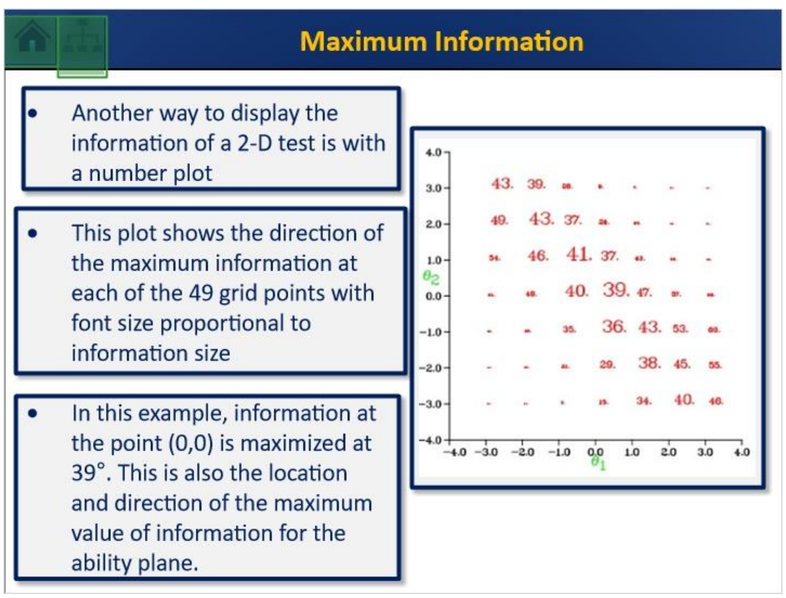
- Clamshell information plot for a standardized math test
- Like in the unidimensional case, the M2PL test information is the sum of the item information values at each (θ_1,θ_2) point at each of the 10 different degree directions
- If two forms were truly parallel, their clamshell plots would be similar after their parameters are put on the same scale



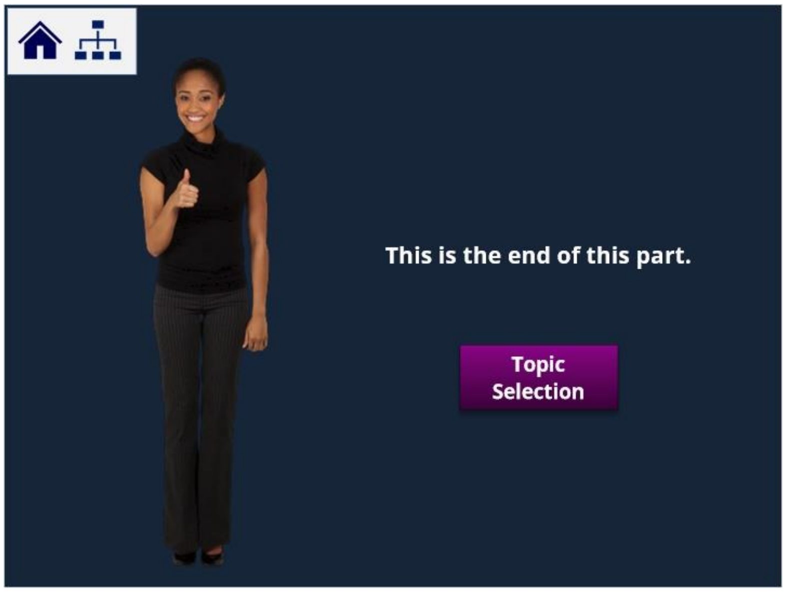
4.25 Clamshell Plots (III)



4.26 Maximum Information

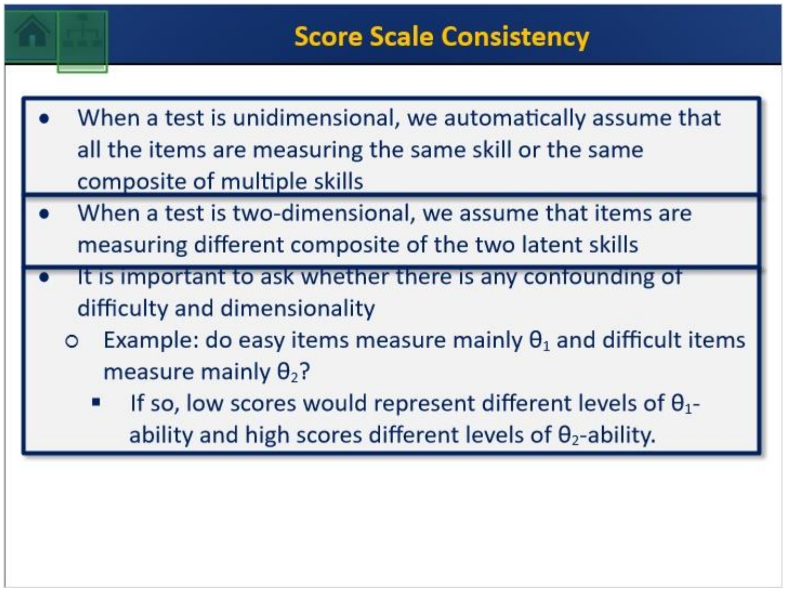


4.27 Bookend: Examining Score Scale Consistency

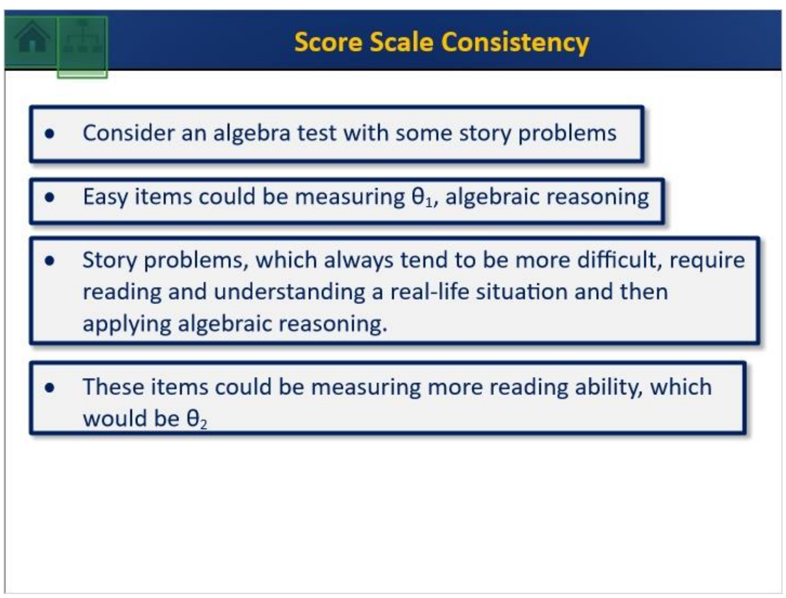


4.28 Bookmark: Examining Score Scale Consistency

4.29 Score Scale Consistency (I)



4.30 Score Scale Consistency (II)



4.31 Conditional Estimation Using Centroids

Conditional Estimation Using Centroids

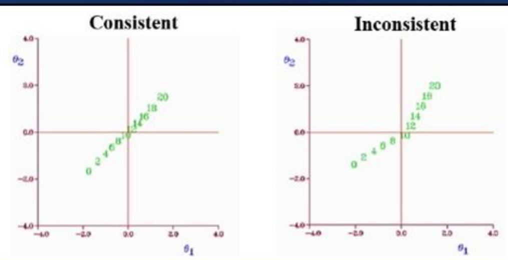
- To gain insight about score scale consistency, we create a centroid plot
- The purpose of this plot is to examine the means of the conditional distributions for each score category:

$$(\bar{\theta}_1, \bar{\theta}_2 | X = x)$$

- The number of the score scale will be printed at the $(\bar{\theta}_1, \bar{\theta}_2)$ of the distribution for all the people with that observed score
- For an interpretation of the score scale to be consistent, the centroid should form a linear pattern

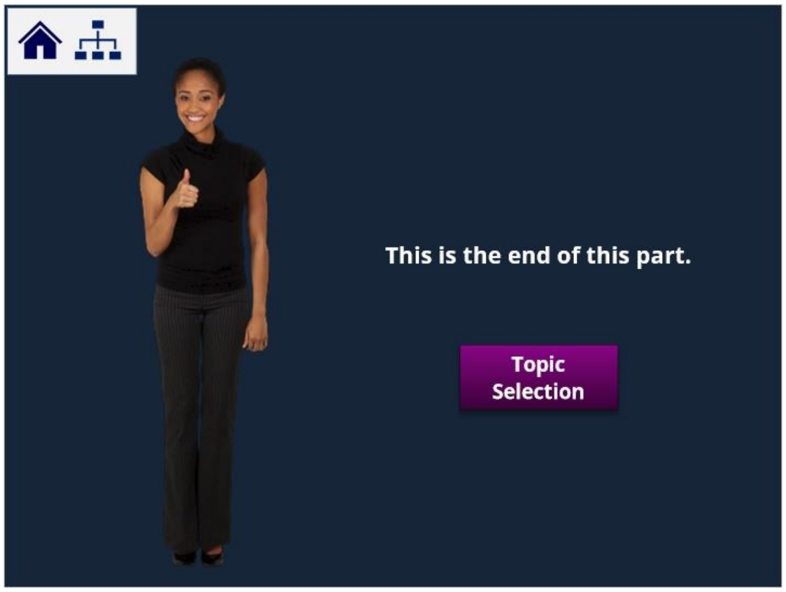
4.32 Centroid Plots

Centroid Plots

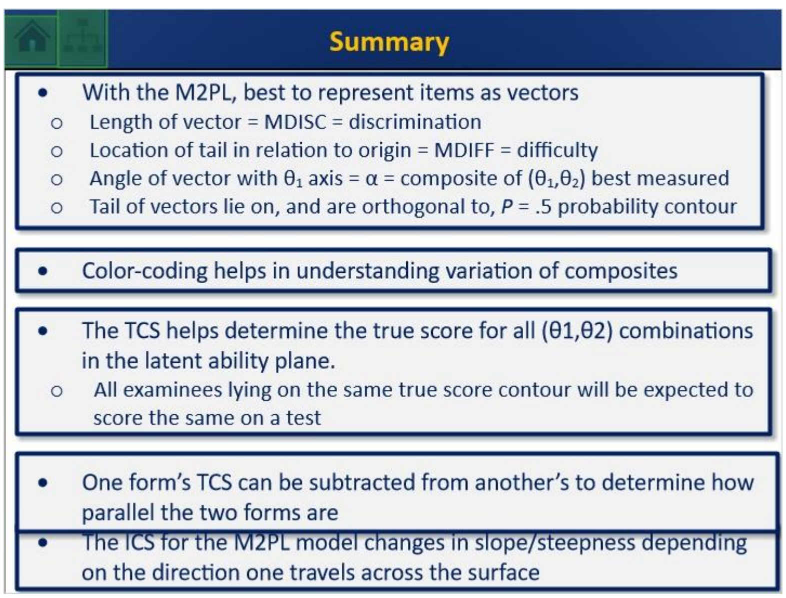


- If the observed score scale is consistent, the centroids will be linear, as shown in the plot on the left
- If the score scale is inconsistent, the plot of the centroids will curve, as shown on the right. Here, differences between low scores tend to be a difference in θ1, and high scores tend to show differences primarily in θ2. This is a case of confounding difficulty and dimensionality.

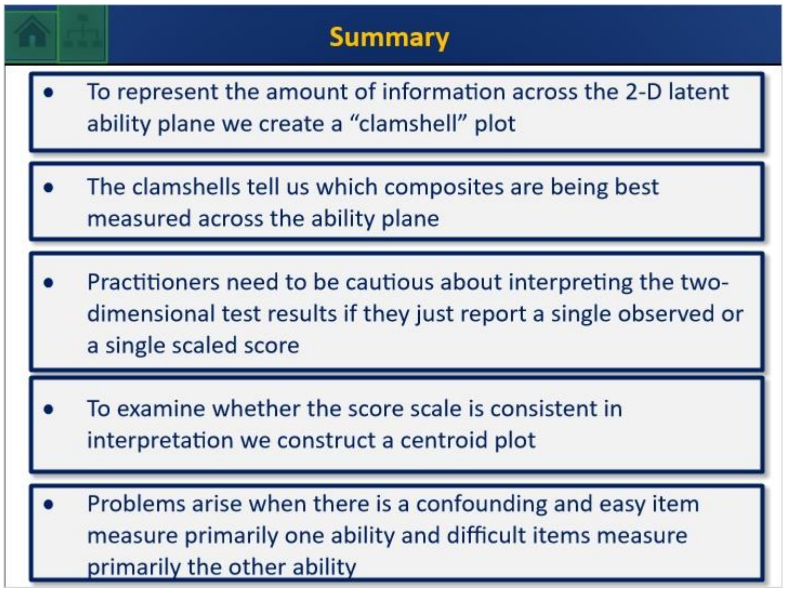
4.33 Bookend: Test Information



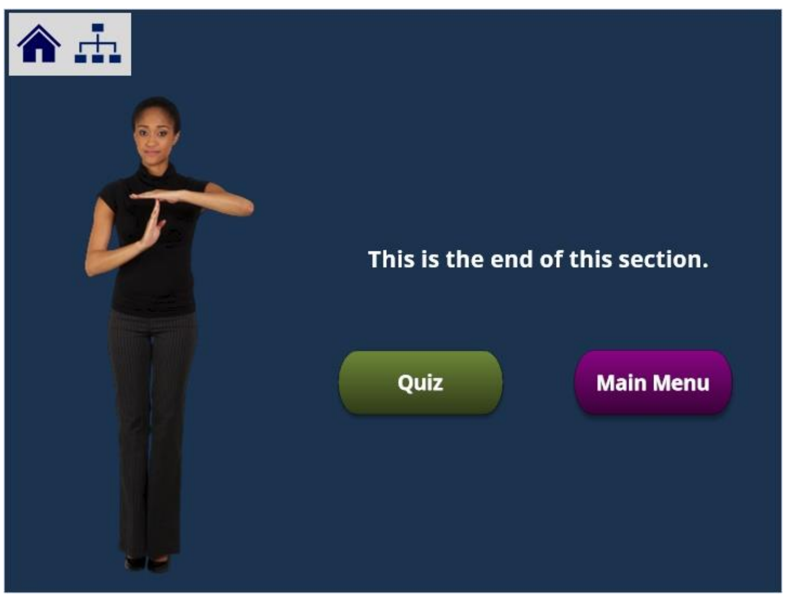
4.34 Summary: Plots for 2D Items and Tests (I)



4.35 Summary: Plots for 2D Items and Tests (II)



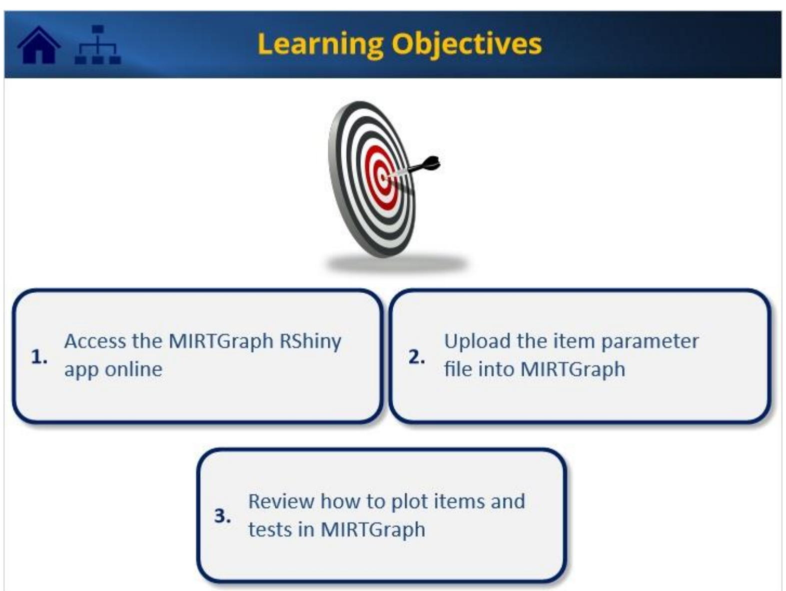
4.36 Bookend: Plots for 2D Items and Tests



5. MIRT Plots in RShiny

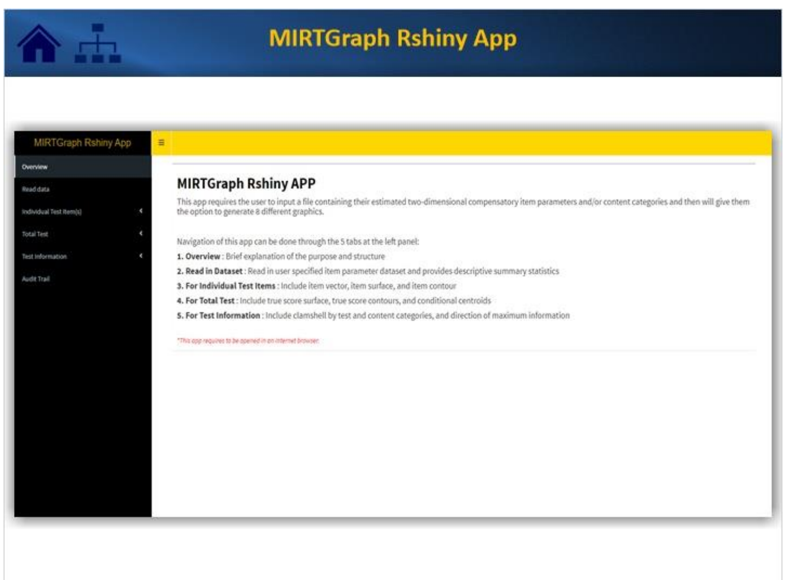
5.1 Cover: MIRT Plots in Rshiny

5.2 Learning Objectives: MIRT Plots in RShiny

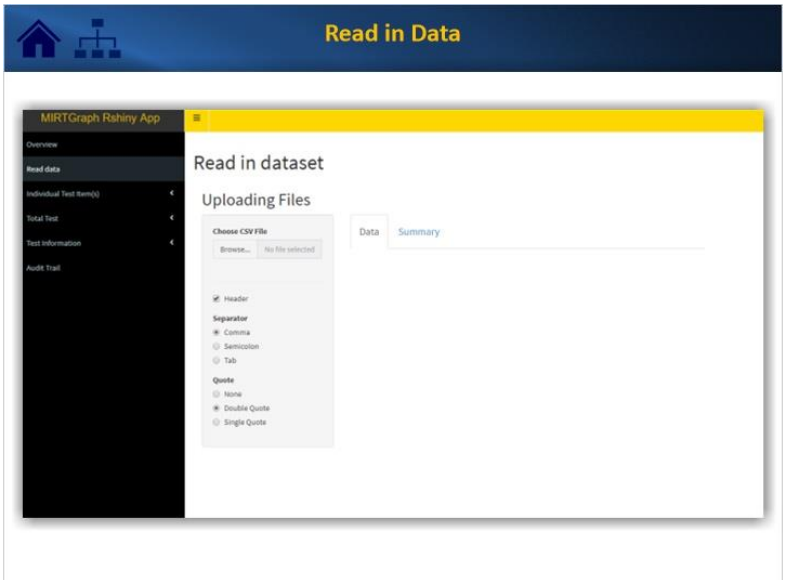


5.3 Access to RShiny

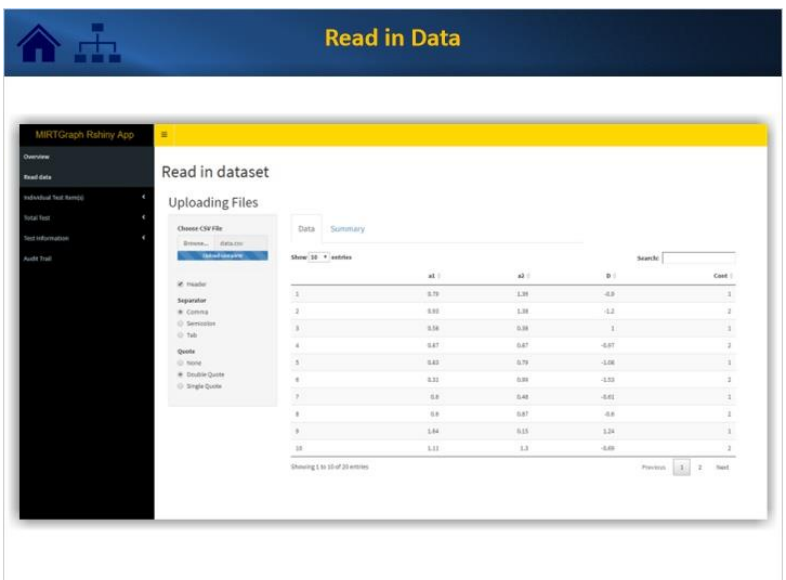
5.4 MIRTGraph RShiny App



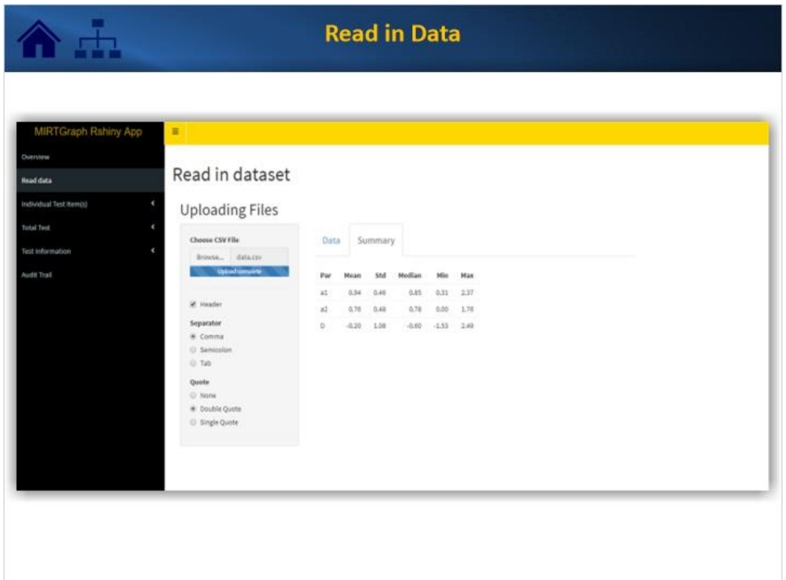
5.5 Read in Data (I)



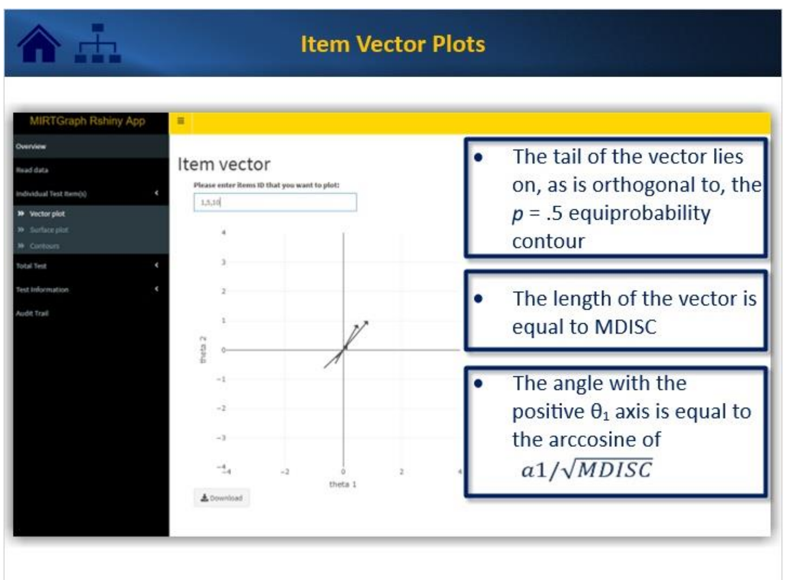
5.6 Read in Data (II)



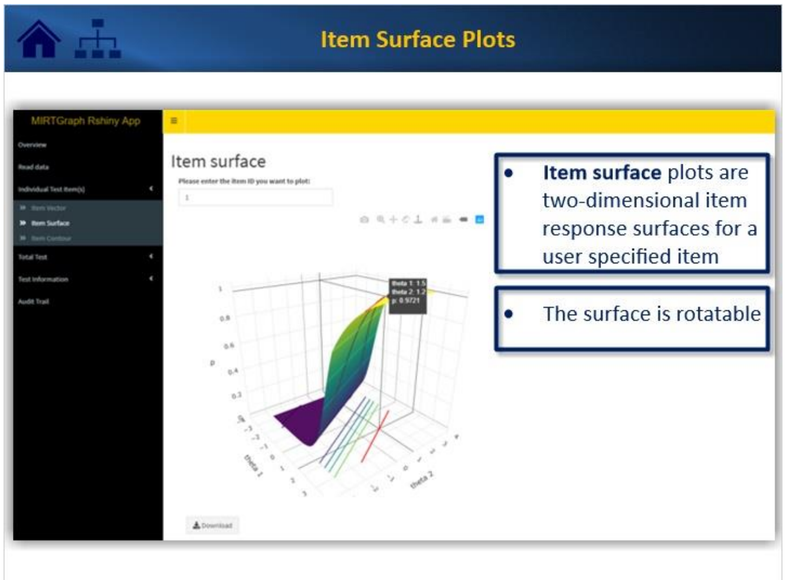
5.7 Read in Data (III)



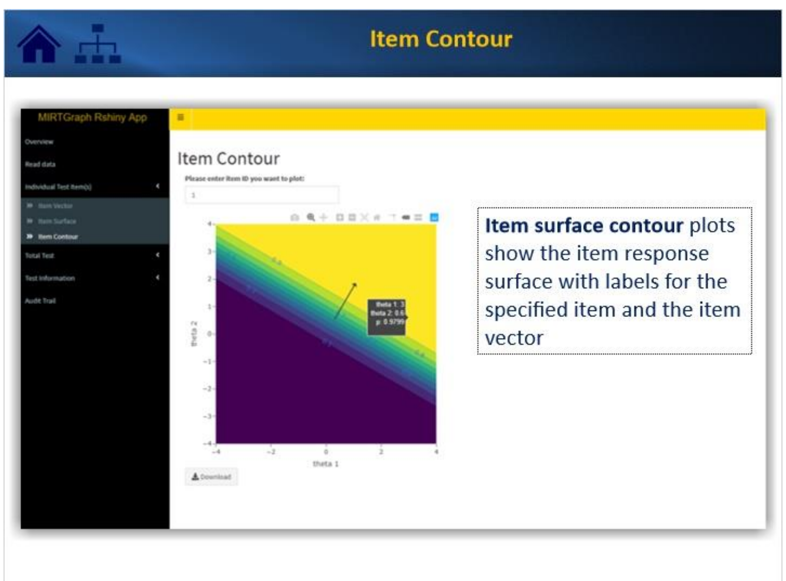
5.8 Item Vector Plots



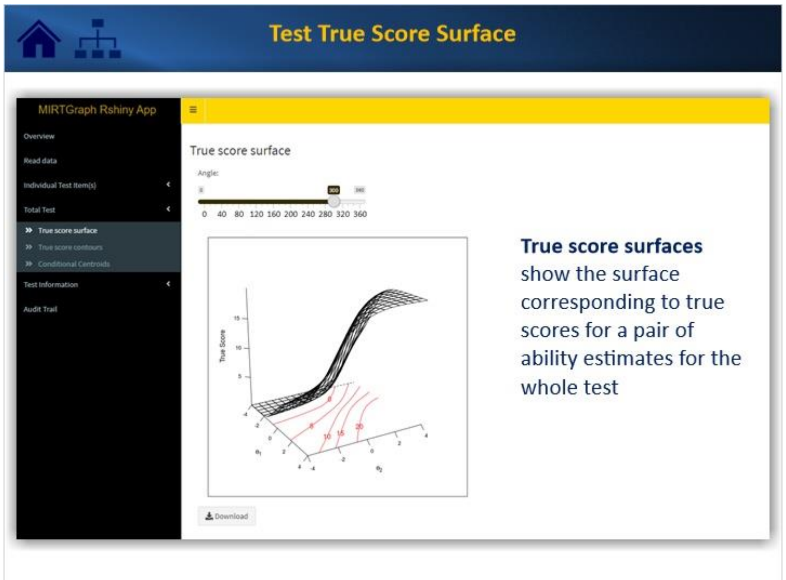
5.9 Item Surface Plots



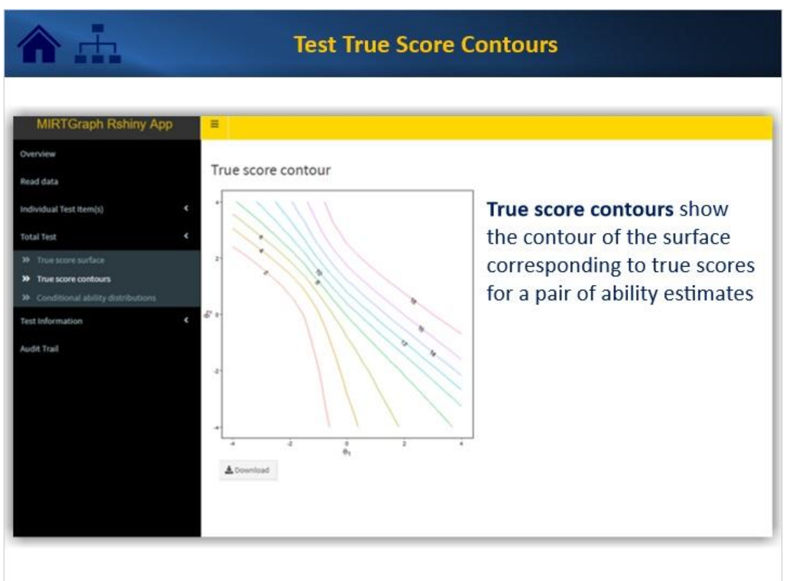
5.10 Item Contour Plots



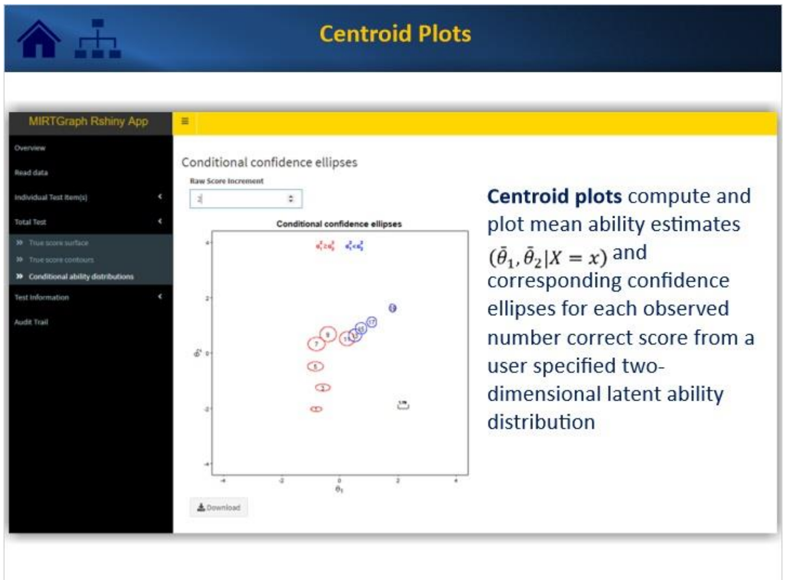
5.11 Test True Score Surfaces



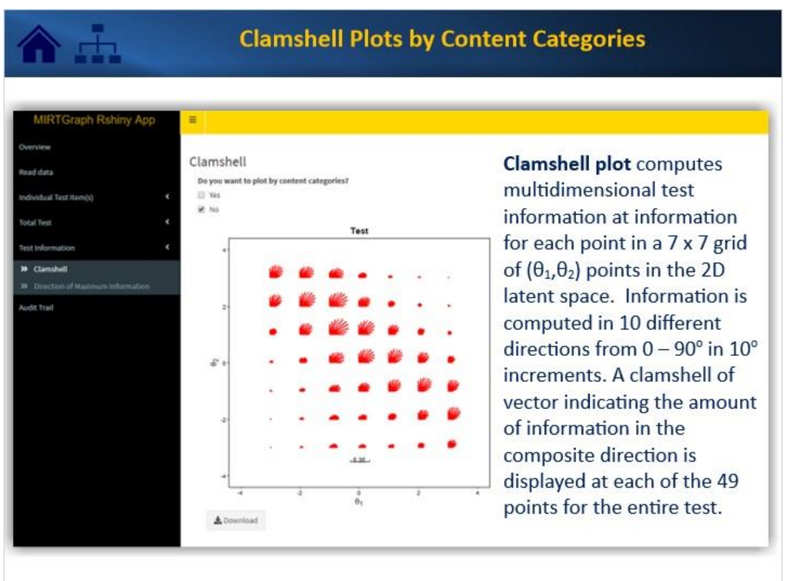
5.12 Test True Score Contours



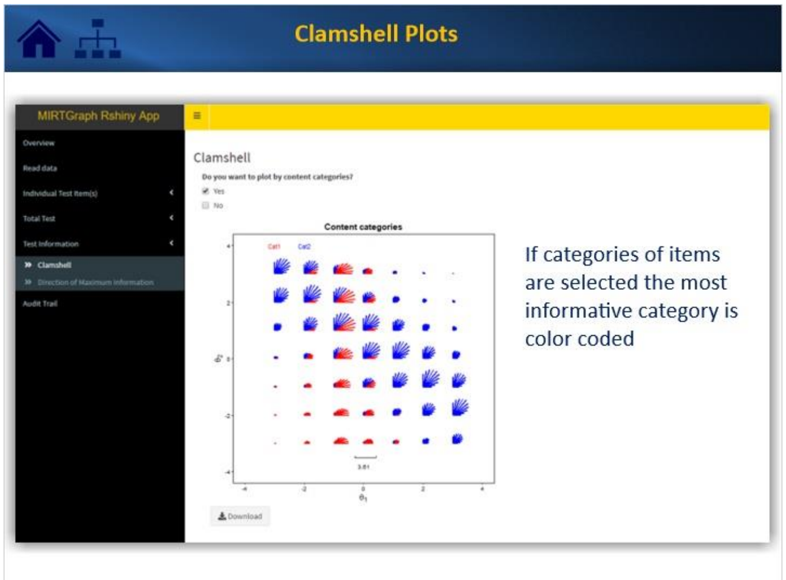
5.13 Centroid Plots



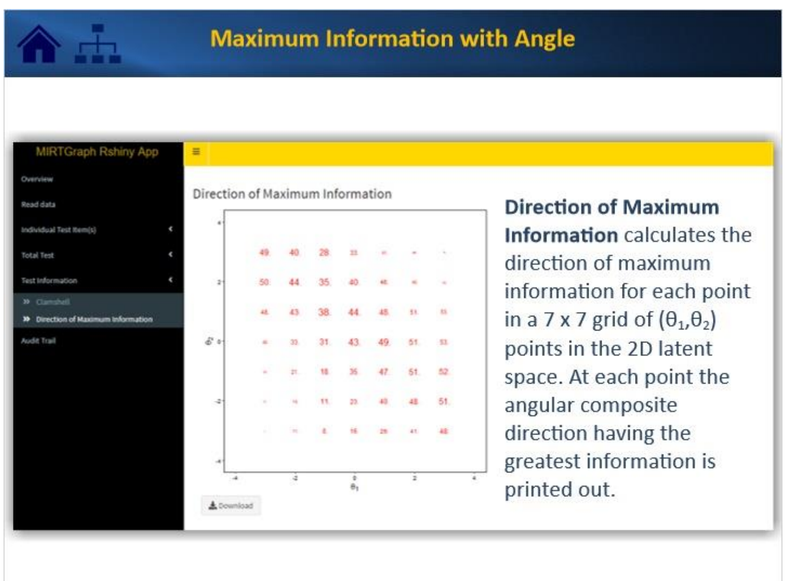
5.14 Clamshell Plots by Content Categories



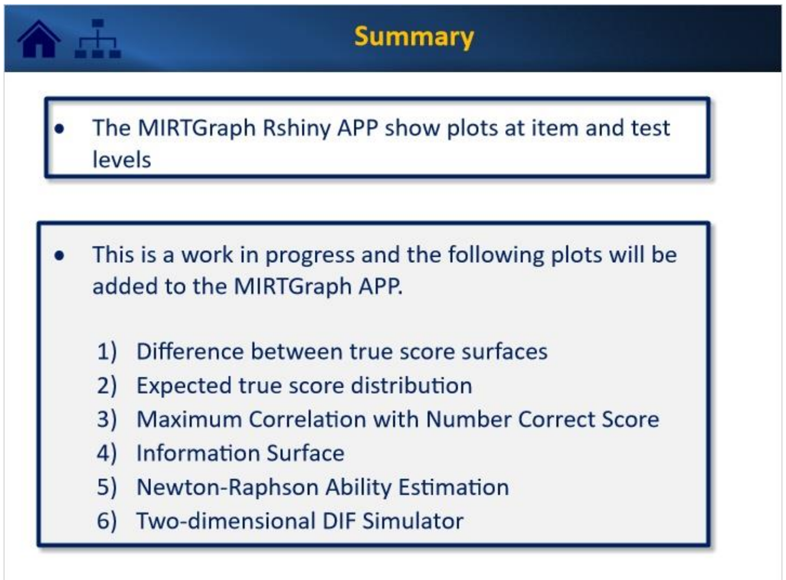
5.15 Clamshell Plots



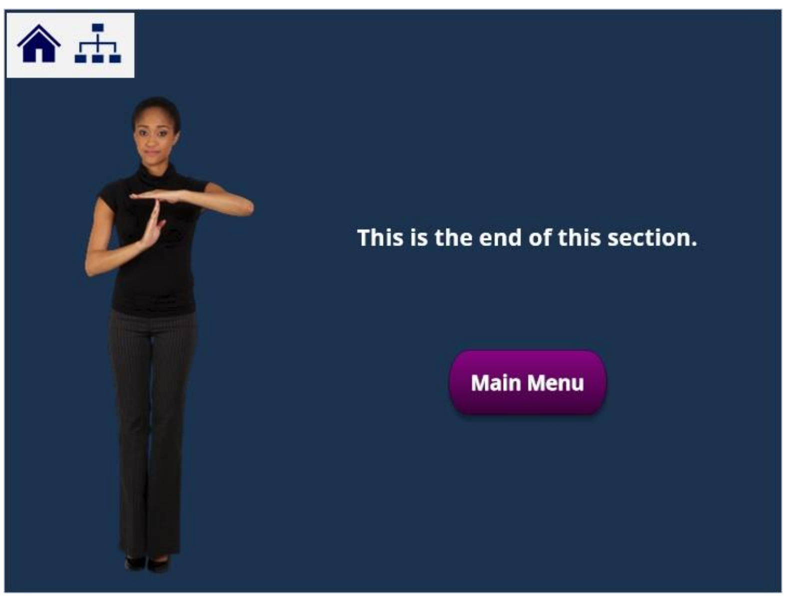
5.16 Maximum Information with Angle



5.17 Summary



5.18 Bookend: Plots for 2D Items and Tests



5.19 Module Cover (END)