

Web application to D-Scoring approach

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1 Introduction

The purpose of this guide is to introduce the methodology of D-Scoring using specially developed Web application. It uses the DScoring package under R, available at <https://github.com/amitko/DScoring.git>. The concepts behind this approach are presented in [1].

The starting screen of the system is presented on Figure 1. It consists of three main areas:

1. Menu - tabs with different aspects of DScoring test assessment
2. Left Pannel - organized in different tabs, it contains different parameters and fields for data input and settings.
3. Right Pannel - the required results are presented. The **Download** button can be used to export the presented results in a **csv** file.

2 Test assessment

The first step of test assessment is to define the used RFM model. The default value (the most common case) is RFM2. After that the file with person's response has to be uploaded. This file should be in **csv** format, with header row. The columns should represent items and the rows - different persons. The value in the row $i + 1$, column j , should be 1 if the person i answers correctly on item j and 0 otherwise. The upload process is presented on Figure 2.

Figure 1: Starting window

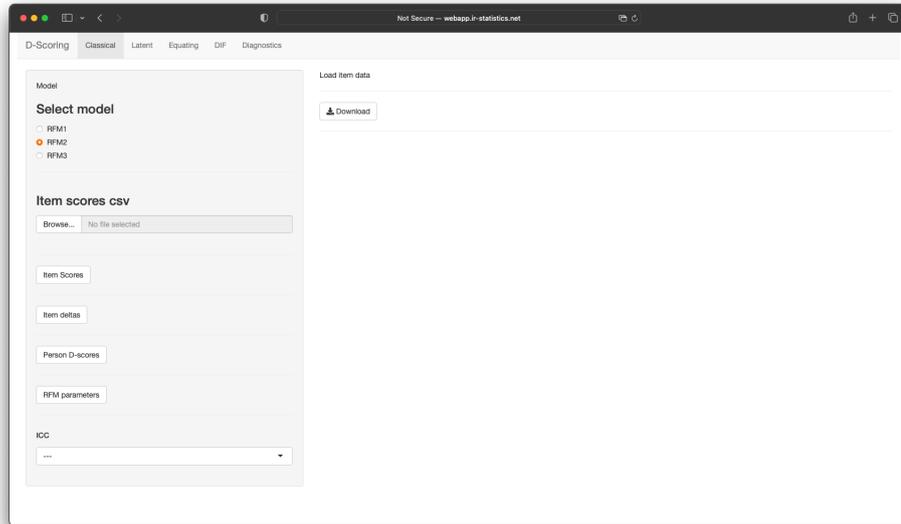
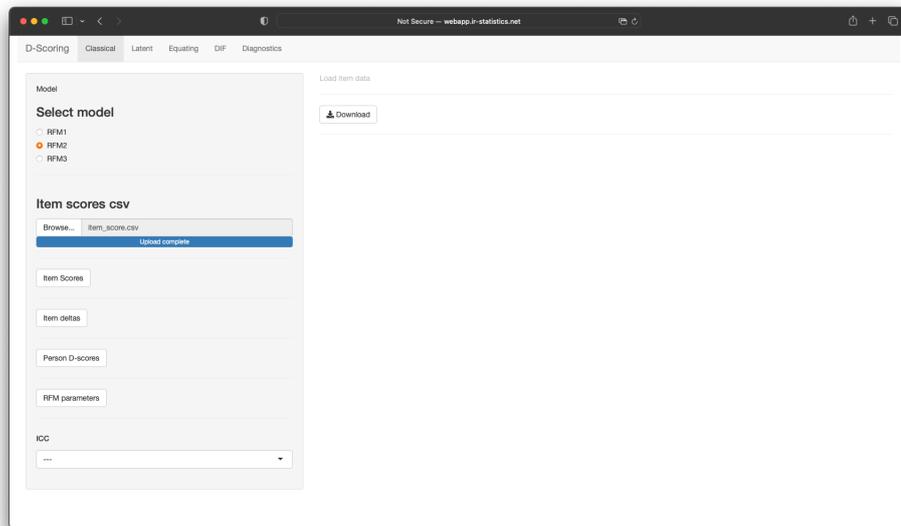
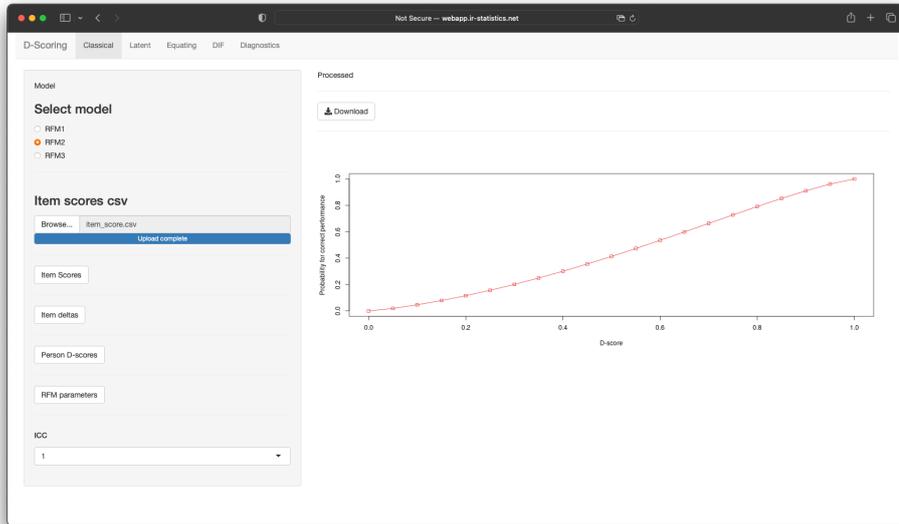


Figure 2: Uploading file



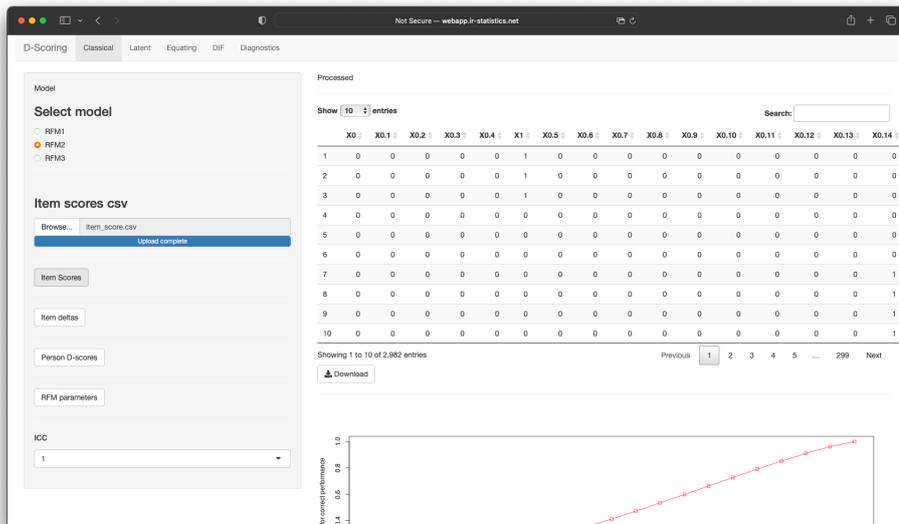
After uploading the file, its processing is started. Depending on the size of the file it may take some time. After the file is processed the status **Processed** is presented in the Left Panel and the ICC of first item is presented (Figure 3).

Figure 3: File is processed



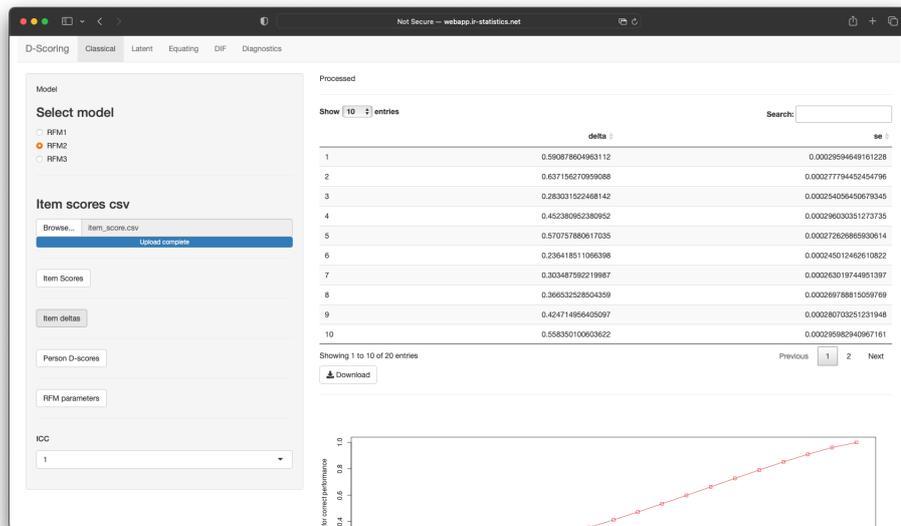
Pressing **Item Scores** in the Left Panel, the uploaded data is presented in the table on the Right Panel. The label of the columns are taken from the first row of the file. In the table only the first 10 rows of the data are presented. Next cases can be accessible on the next pages. The whole file can be downloaded using **Download** button. See Figure 4.

Figure 4: Item scores



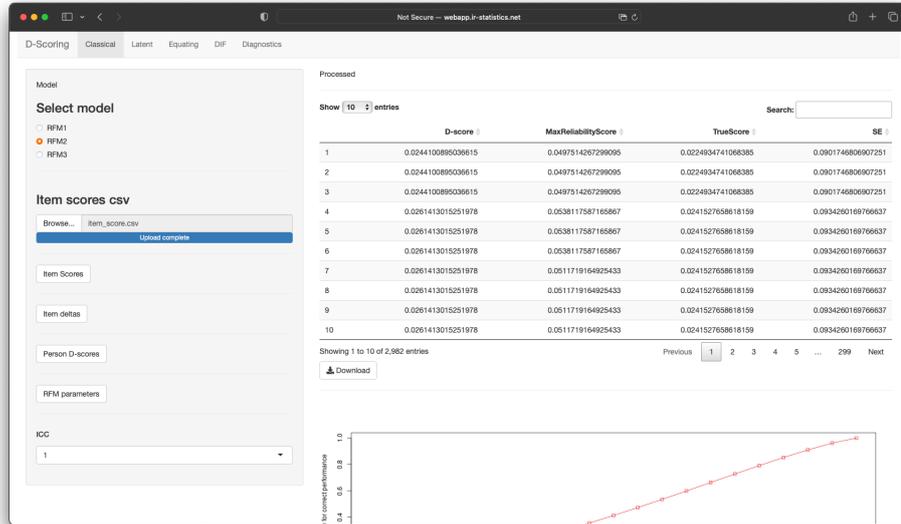
The estimated item deltas can be accessed by pressing the **Item deltas** button in the Left Panel (Figure 5). On the right the corresponding values of the item delta are presented. The first column shows the estimated delta value while the second column is the corresponding standard error (se) of the estimate.

Figure 5: Item deltas



Estimated person's D-scores can be shown by pressing the **Person D-scores** (see Figure 6) button in the Left Panel. The data presented on the Right Panel consist of estimated person's D-score, the maximum reliability D-score (see [2]), estimated true score and standard error of estimated D-score.

Figure 6: Person D-Scores



The data from the current test are fitted to the chosen RFM model. The fit parameters are presented by pressing **RFM parameters** button on the Left Panel (see Figure 7). The presented data consist of estimated item parameters and their standard errors as well as of a MAD of the estimated fit.

The item characteristic curve for the specific item can be shown choosing the item from the ICC list box (Figure 8). The plot can be exported with right click.

Figure 7: ICC

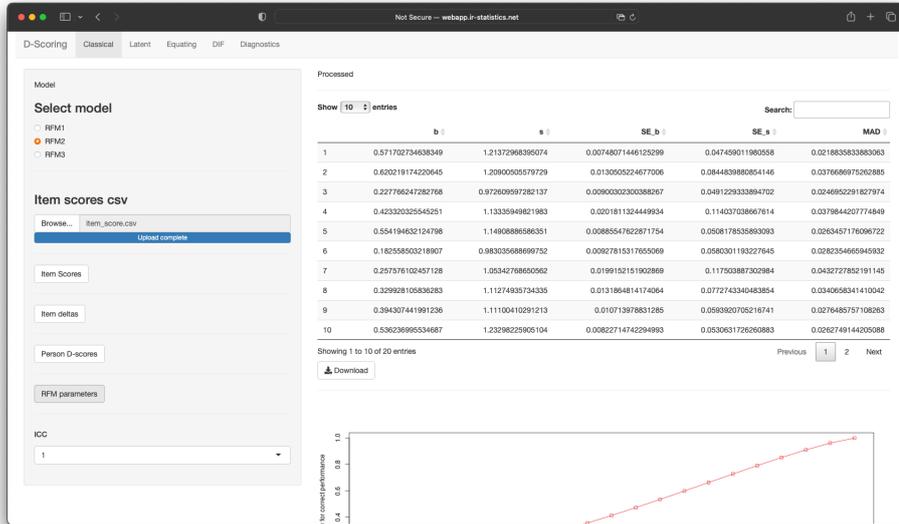
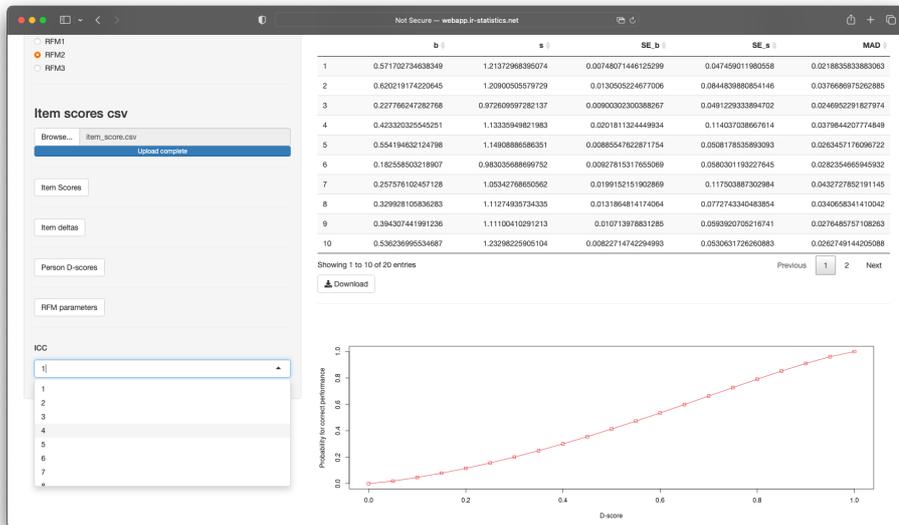


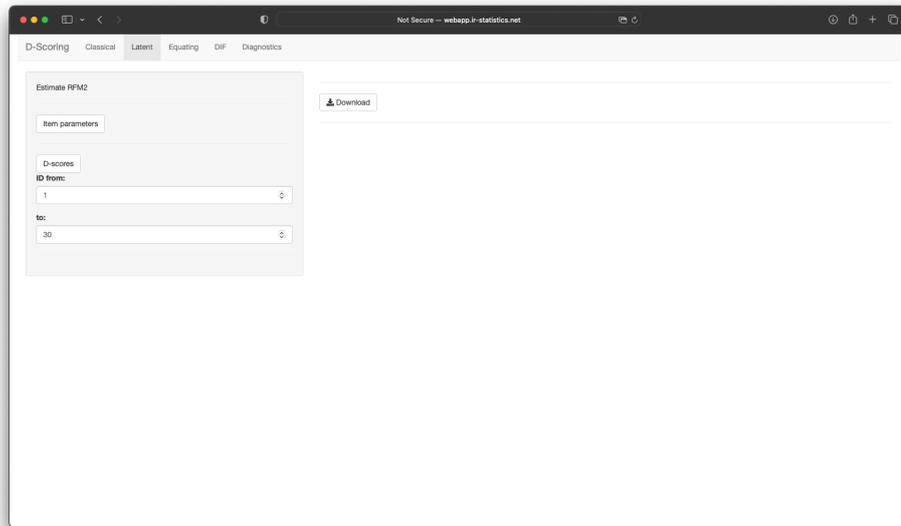
Figure 8: RFM fit



The item parameters as well as a person parameters are accessible from the second tab of Latent (Figure 9).

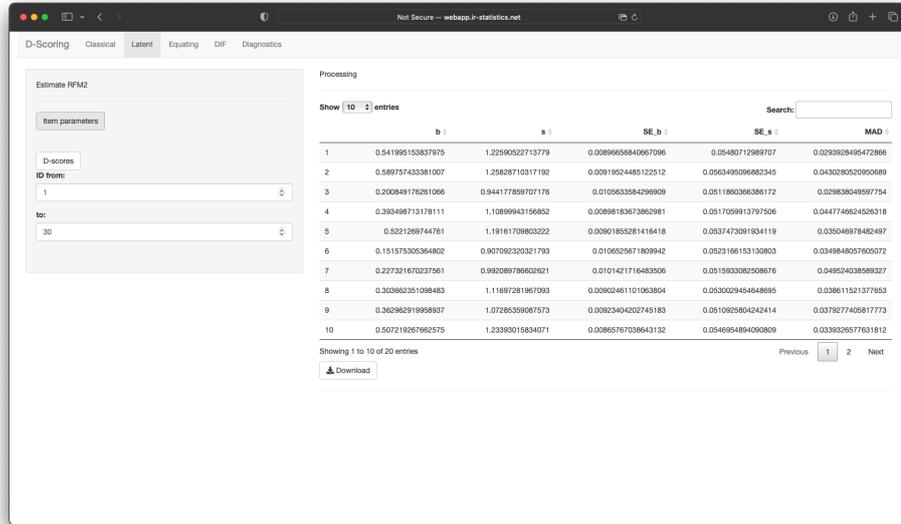
3 Estimation of the latent model

Figure 9: Latent parameters



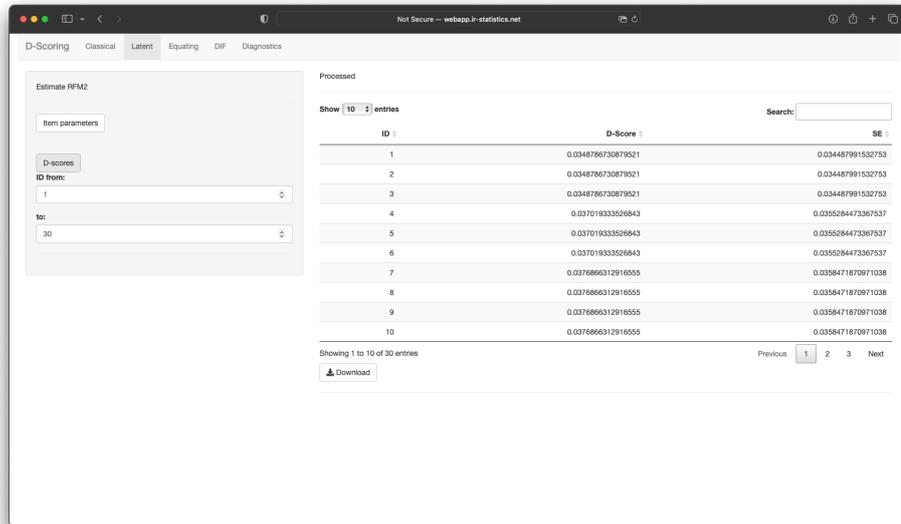
Latent item parameters can be shown via button **Item parameters** (Figure 10). The estimated item parameters, according to the chosen RFM model are presented as well as their standard errors (SE). The last column of the table contains the estimated mean absolute difference (MAD) between observed item performance and the one predicted by the model.

Figure 10: Latent item parameters



The estimated person parameters can be accessed by the button **D-scores**. The proposed methodology is explained in [3]. As the calculation of their values is computably intensive, only the specified range **ID from - to** of person ID (rows in the data file) are processed. For example, if one wants to process the first 150 persons (rows) in the data file, one should input values 1 and 150 in these fields. The result is presented on Figure 11. The first column consists the person ID (row number), so if the data file is large, different bunches of it can be processed separately and the results can be combined together based on this column. The second and third column are the estimated D-Score and its standard error.

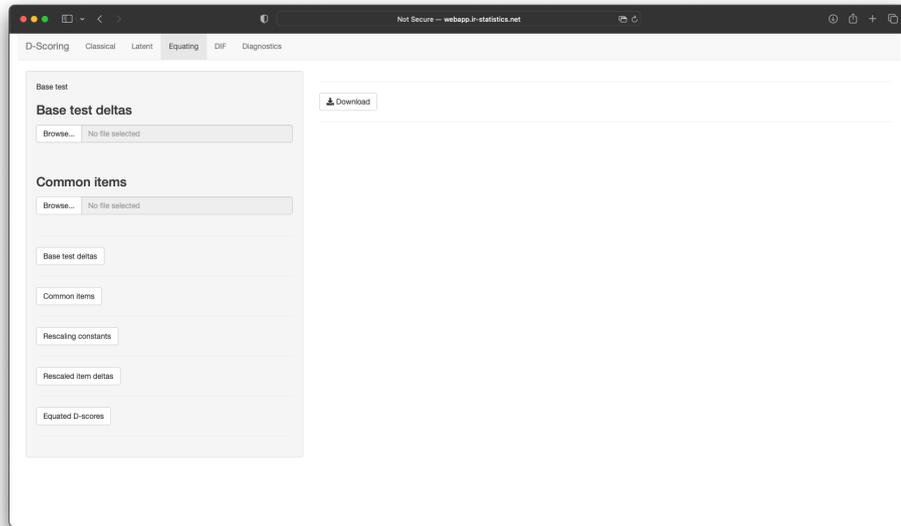
Figure 11: Latent person parameters



4 Test equating

One of the main advantages of the used methodology is the ability to equate the results of different test forms, administrated on different populations (see [5]). For that purpose, the item deltas for the base test (the test to which the current test is equated) should be provided as well as the set of comon items between the two tests (Figure 12).

Figure 12: Test Equating

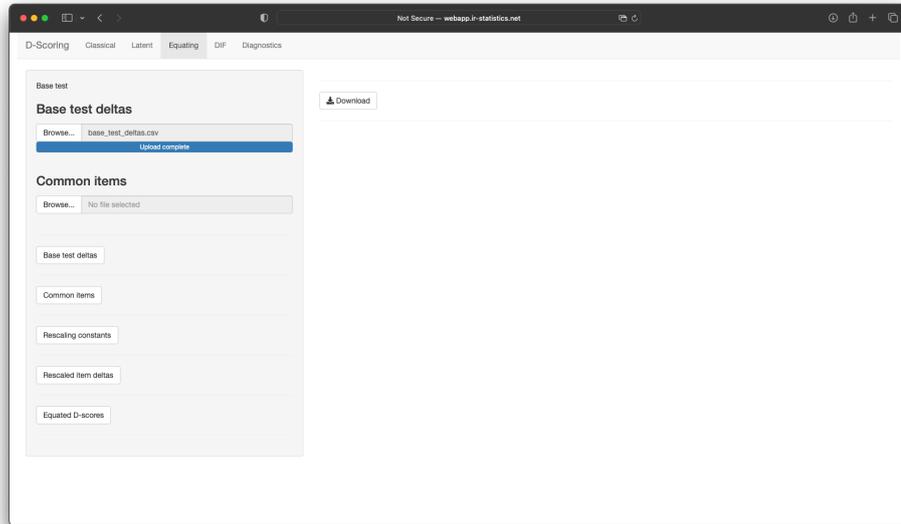


The base test item deltas should be provided in a `csv` file as a one column with a header row, for example

```
"delta"  
0.146036509127282  
0.623155788947237  
0.706426606651663  
0.295073768442111  
0.60190047511878  
0.695923980995249  
.  
.  
.
```

The file should be uploaded in the field `Base test deltas`, (see Figure 13).

Figure 13: Base test deltas



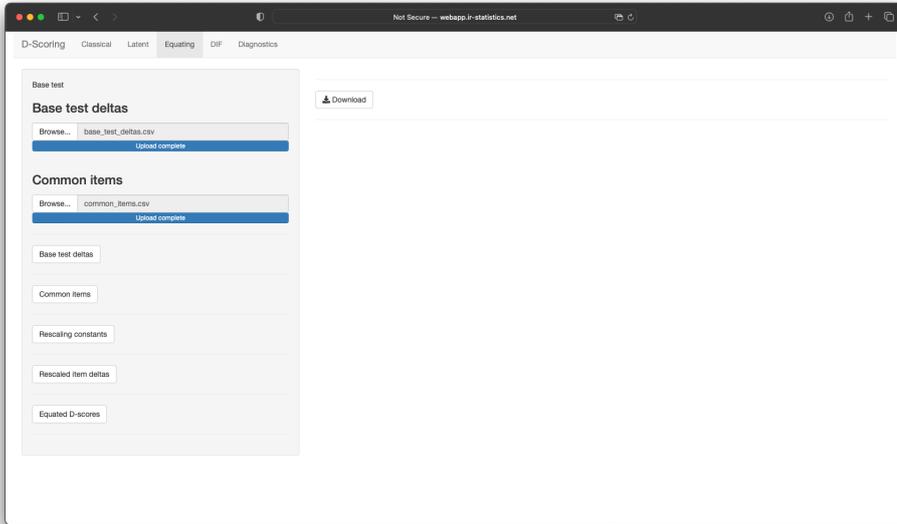
The common item should be provided in a `csv` file with two columns. The first one indicates the number of the item i the base test which is equivalent to the number of the item in the current test, presented in the second column.

For example, the following file

```
3,5  
7,9  
4,6  
7,3
```

shows that item 3 from the base test is equivalent to item 5 in the current test under processing, item 7 in the base test corresponds to item 9 in the current and so on. The file should be uploaded in field `Common items` (Figure 14).

Figure 14: Common items



The loaded base test deltas and common items can be inspected with the corresponding buttons, see Figure 15 and Figure 16.

Figure 15: Base test deltas inspected

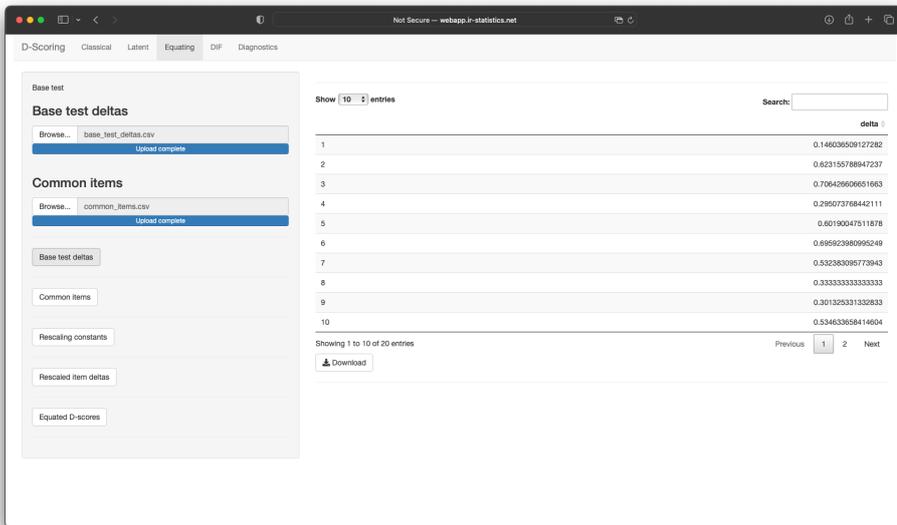
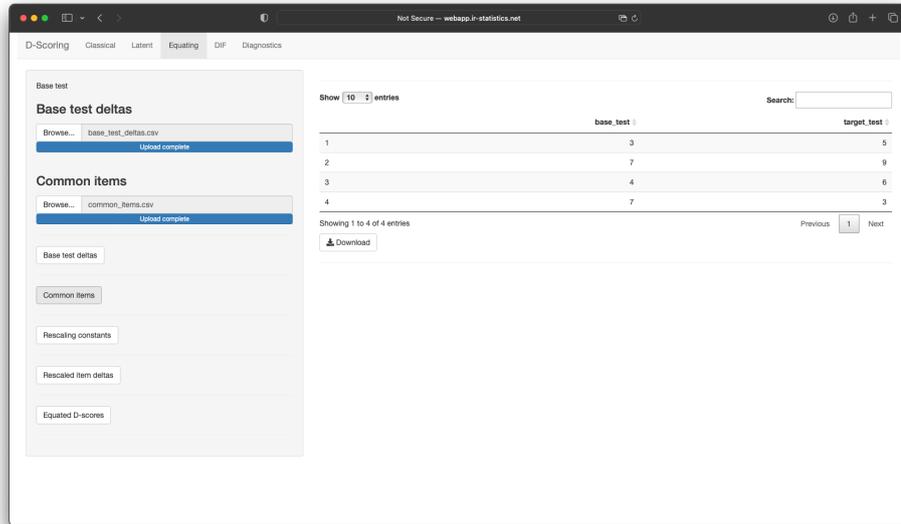


Figure 16: Common items inspected



Equating constant A and B are presented on Figure 17. The current test item deltas, rescaled on the scale of the base test are available through button Rescaled item deltas (Figure 18). The equated person's D-score can be shown by Equated D-score button (Figure 19).

Figure 17: Equating constants

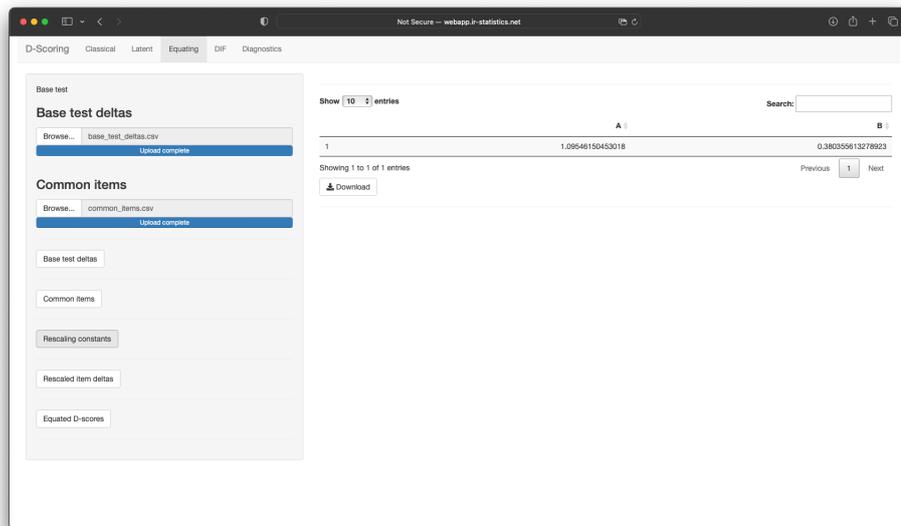


Figure 18: Rescaled Item deltas

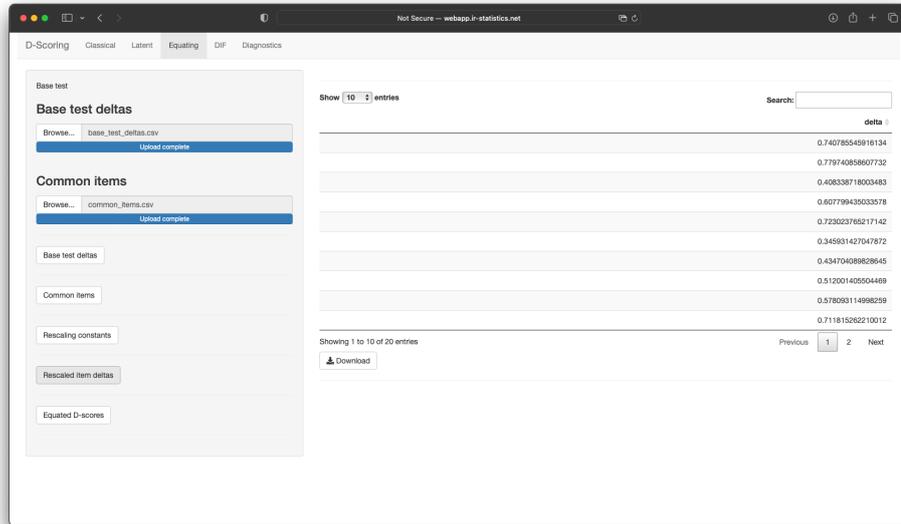
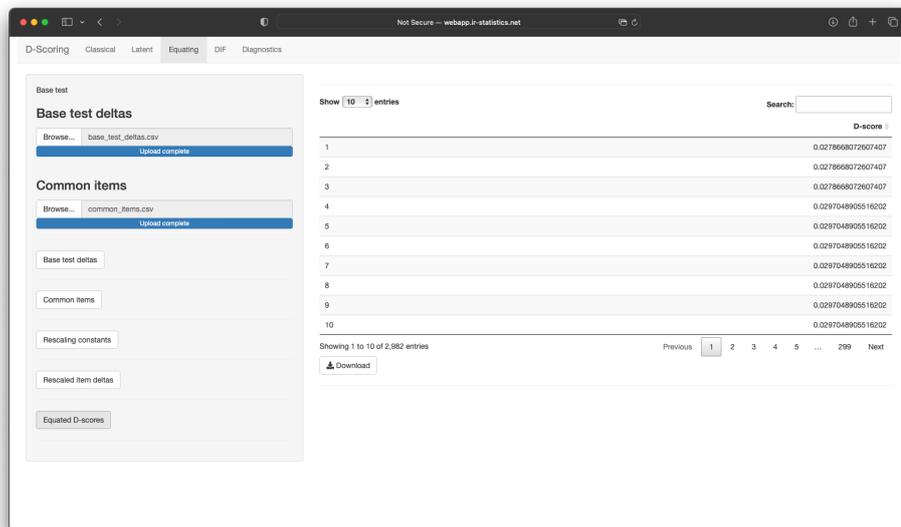


Figure 19: Equated person score



5 Differential item functioning

Differential item functioning of the items in the current test can be studied by DIF tab of the application (Figure 20). Detailed description of the method-

ology and the interpretation of the results can be found in [4]. The focal and reference group should be indicated by the `csv` file with a focal indicator (Figure 21). This file should contain one column with value for every person in the test indicating whether he belongs to the focal (value 1) or reference group (value 0). So the file consists of one single column with zeros and ones.

The resulted DIF statistics can be shown by button **Statistics** and the result is presented on Figure 22. If there is a statistically significant DIF for a specific item, the corresponding value in the column DIF will be 1.

Figure 20: DIF

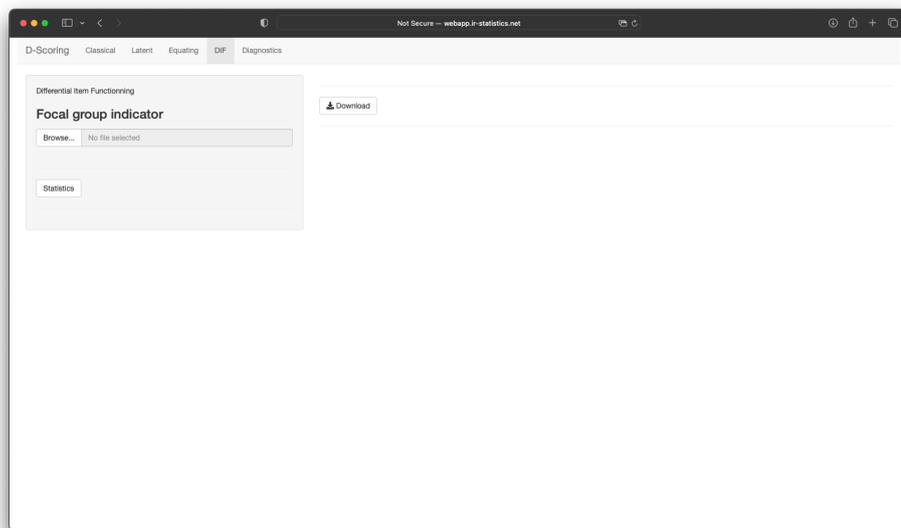


Figure 21: Focal indicator

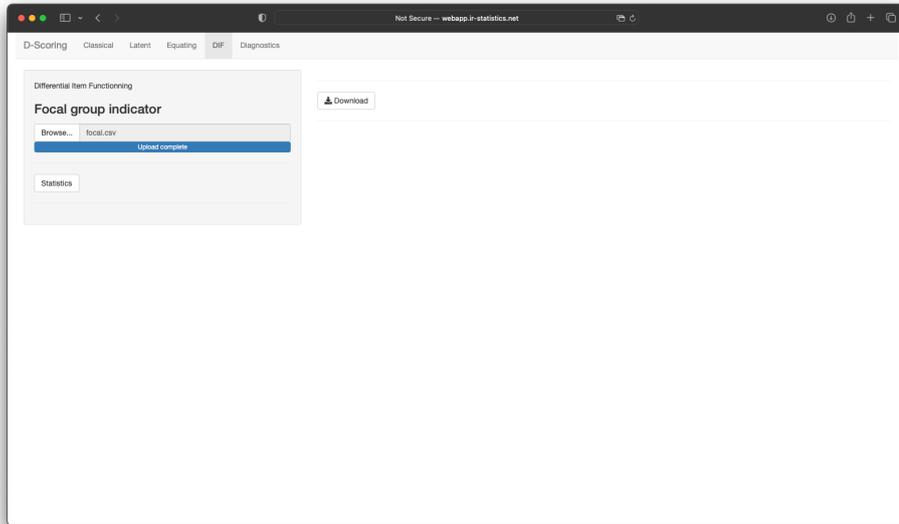
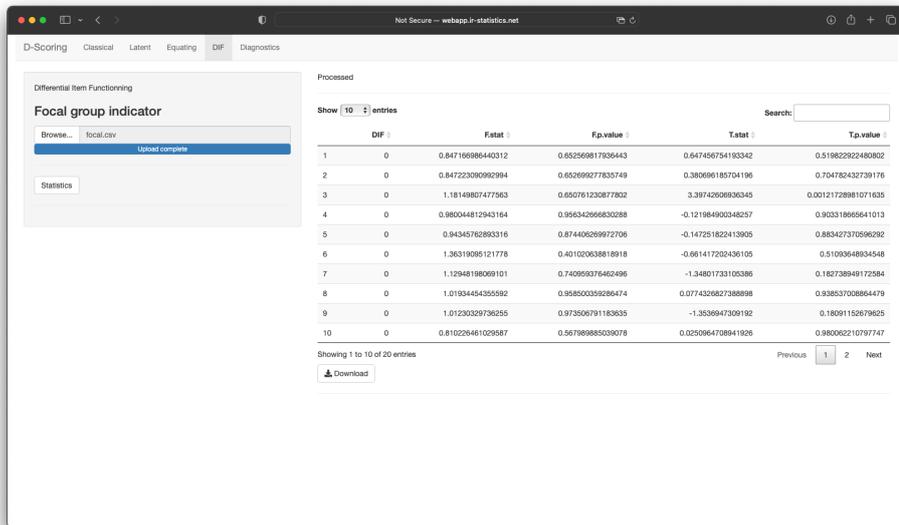


Figure 22: DIF Statistics



6 Test diagnostics

A basic test diagnostics can be achieved by 'Item-Person map' available at the tab Diagnostic, presented on Figure 23. The result is presented on

Figure 24. The bars, labeled as 'deltas', represent the distribution of the item difficulties, while the bars labeled as 'D-score' represents the distribution of the estimated D-score of the persons.

Figure 23: Diagnostics

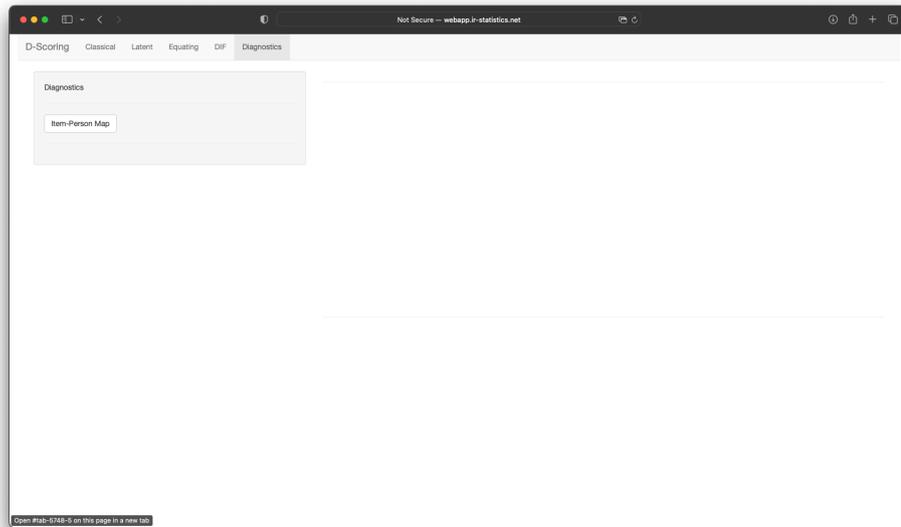
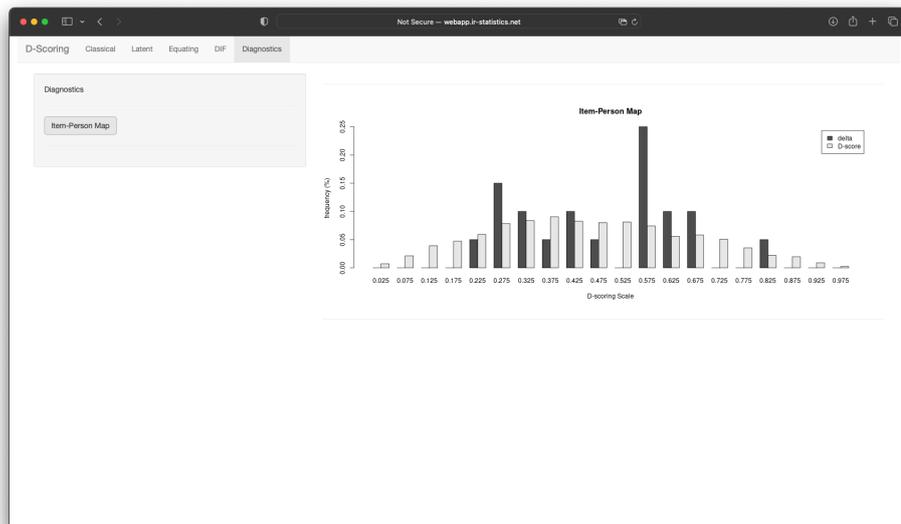


Figure 24: Item-Person map



References

- [1] Dimitrov, Dimiter. (2019). Modeling of Item Response Functions Under the D -Scoring Method. Educational and Psychological Measurement. 80. 001316441985417. 10.1177/0013164419854176.
- [2] Tenko Raykov, Siegfried Gabler, Dimiter M. Dimitrov (2016) Maximal Reliability and Composite Reliability: Examining Their Difference for Multicomponent Measuring Instruments Using Latent Variable Modeling, Structural Equation Modeling: A Multidisciplinary Journal, 23:3, 384-391, DOI: 10.1080/10705511.2014.966369
- [3] D. Dimitrov, Dimitar Atanasov. 2020. *Latent D-Scoring Modeling: Estimation of Item and Person Parameters*. Educational and Psychological Measurement. WoS.
- [4] D. Dimitrov, Dimitar Atanasov. 2021. *Testing for Differential Item Functioning Under the D-Scoring Method* . Educational and Psychological Measurement. WoS.
- [5] Dimiter M. Dimitrov & Dimitar V. Atanasov. (2021), *An Approach to Test Equating under the Latent D-scoring Method*. Measurement: Interdisciplinary Research and Perspectives. 19:3. 153-162,. WoS.