Regional Module User Manual

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February 2016

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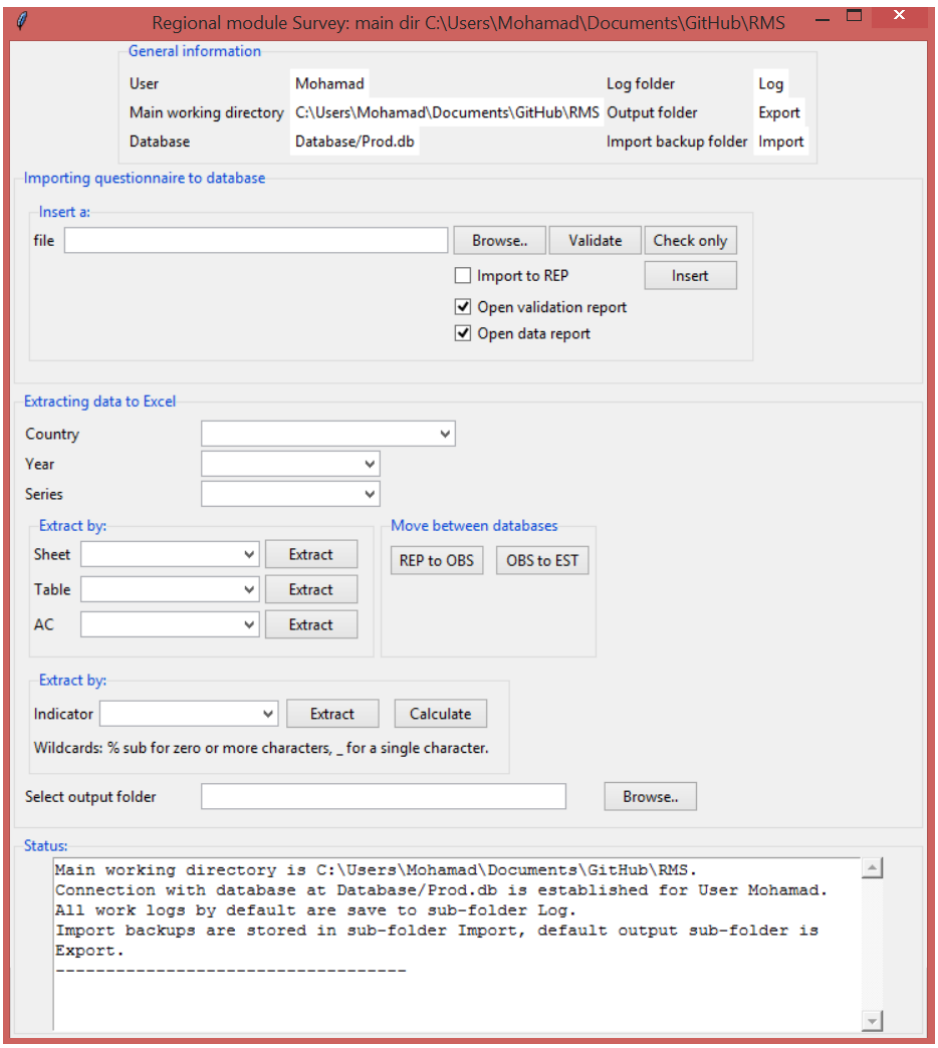


Figure 1: Screen shot of RM_GUI.

1 Regional Module Graphical User Interface (GUI)

This document explains how to use the management system GUI of the Regional Module (RM). There are four main frames in the GUI that could be seen in Figure 1.

- General information: general session and user information as the user name and database location, main working directory, ..etc.
- Importing questionnaire to the database: tools to import or validate a single questionnaire.
- Exporting data or indicators to Excel: tools to export and visualize the raw data or indicators that are already in the database.
- **Status**: a panel that outputs updates on the carried procedures, including any errors. Shown in the bottom of the interface.

Sidebar

In this guide you will learn to:

- Import questionnaires.
- Export and and view data for cleaning.
- Move data between series.
- Calculate and view indicators.

Each frame, excluding the Status panel, has a specific subsection below that explains in details how to use the available tools.

1.1 General information

This frame holds information that are essential for all tools in other frames, and will be used all over this guide.

- **User** prints the automatically retrieved user name from the windows login information. This user name is used to track user changes to the data as will be later explained.
- **Main working directory** is the path of the main folder where all the other mentioned sub-folders are located. Basically, it is the folder that contains all the software, from code to documentation.
- **Database** shows the path to the physical database (`.db` file). In Figure 1, it is in the sub-folder `Database` of the main folder as indicated by `/Database/Prod.db`. For example if the main directory is `/Desktop/RMS` then the database file is at `/Desktop/RMS/Database/Prod.db`.
- **Log folder** holds validation and data reports every time a user attempts validate, check only or insert the data. It is also a sub-folder of the main directory. See Sections 1.4 and 1.5 for more details.
- **Output folder** is the default folder where exported Excel workbooks are saved if no other folder is specified. *Note that you can specify another output folder, see note in Exporting data options.*
- **Import backup folder** holds backups of every inserted Excel workbook. A copy of the Excel workbook is saved with time and date stamps attached to its name.

Note

- Data in the General information frame are only editable from the scripts, not from the GUI.
- Only the **Output folder** folder is editable through the export panel, see note in Exporting data options.

1.2 Importing questionnaire to the database

To Insert a questionnaire to the database, follow these steps:

1. Click on the `Browse..` button that is adjacent to `file` label and select a file.
2. Validate the file by clicking on `Validate` button, since there are specific pre-processing checks to make sure that it conforms with the coding scheme. If the checks are passed, the Status panel will indicate with a note on the lines of

   ```
   Validation successful, see report in:
   Log/Lao People's Democratic Republic_16-01-22-11-33_validation.txt
   ```

   otherwise on the lines of

   ```
   Pre-processing validation failed. Some errors exist see log file in:
   Log/Lao People's Democratic Republic_16-01-22-11-35_validation.txt
   ```

   In both cases a validation report is saved in the `Log folder`, and should automatically open if the box `Open validation report` is ticked.
3. If validation passed, insert the questionnaire by clicking on `Insert`. The file is inserted to the database and a `csv` data report is generated and saved in the `Log folder`, and also should automatically open if the box named `Open data report` is ticked. A note on the lines of

   ```
   INSERTION STEP

   Inserting C:/Users/Mohamad/Documents/GitHub/RMS/Import/
               RM_Lao People's Democratic Republic_2015_15-11-19-23-46.xlsx
   Checking that region values add to the country value...Test passed.
   Checking that parts are less than the totals...Test passed.
   Checking sums of columns...
   ----------Questionnaire Insertion finished.----------.

   Data report written to:
   Log/Lao People's Democratic Republic_16-01-22-11-40_data_report.csv
   ```

   will appear in the Status panel.

The steps above are simplified. For more details about the pre-processing checks and data report please refer to Sections 1.4 and 1.5.

Note

- Note that only files with `.xlsx` extensions are inserted.
- A copy of any inserted file is saved to the `Export` sub-folder with time and data stamps attached to their names to indicate the time of importing.
- All validation files and data reports are saved to the `Log folder`, while some information is shown in the Status panel.

About the checkboxes:

- **Import to REP** is a security checkbox that stops the user from inserting to the reported series (REP) by mistake. It is unticked by default, and works as follows, if the user attempts to insert some data to the reported series, even if the file validates, the user is not allowed unless this checkbox is ticked. Only under one exception is it allowed, if the inserted file is an original questionnaire, this become more clear in Exporting data options.
- **Open validation report** is a checkbox that is ticked by default to automatically open the validation report resulting from the validation step. Feel free to untick it as all the validation reports are saved in the `Log folder`.
- **Open data report** is a checkbox that is ticked by default to automatically open the date report resulting after inserting a questionnaire. Feel free to untick it since all data reports are saved to the `Log folder`.

Finally, the button `Check only` allows the user to produce a data report without validating nor inserting the data. The objective is to streamline the cleaning process before finally inserting the data.

1.3 Exporting data or indicators to Excel

1.3.1 Choosing a country name, year and series

The `Country` drop-down list will only show names of countries with data already in the database. This drop-down list has a live connection to the database, thus if one inserts a questionnaire for a new country, as shown in a Importing questionnaire to the database, the country's name should appear in the drop-down list directly.

Once a country name is selected, the `Year` drop-down list shows years with available questionnaire data for the selected country.

The series drop-down list has three options:

1. Reported (REP): where the original questionnaire is inserted, given that no person has changed or modified any of the data in this series. It is advised to only modify data in the Observed series, thus the checkbox `Import to REP` is created.
2. Observed (OBS): where the user is advised to modify and validate the data.
3. Estimated (EST): where the disseminated data set should be, **since the indicators are calculated from this series only**.

1.3.2 Moving data between series

An original questionnaire is always inserted to the *Reported* series, to move it the *Observed* or *Estimated* series, choose first the country and then year, and then click on the buttons in the `Move between databases` frame.

- `REP to OBS` would move the data from *Reported* to *Observed* series.
- `OBS to EST` would move the data from the *Observed* to *Estimated* series.

1.3.3 Exporting data options

Important

This section is important because is contains many necessary details to understand how the whole GUI works.

There are three ways to export data, sheet only, table only and alphanumeric code (AC) only. Each way has its own drop-down list.

Sheet A drop-down list of all exportable questionnaire sheet names. Once a sheet is selected click on the adjacent `Export` button to export it to a new Excel workbook. To export all available sheets select `All` from the drop-down list.

Table A drop-down list with all tables of the questionnaire. By selecting one and clicking on the adjacent `Export` button a new Excel workbook is created that holds the selected table.

AC A drop-down list with all alphanumeric codes (AC) that are in the questionnaire. By selecting one and clicking on the adjacent `Export` button a new Excel workbook is created that holds the data.

Note

- The exported workbooks are by default saved to `Export` sub-folder of the main directory, with the naming convention `County Name-Year-Exported Variable-Series.xlsx`.
- Users can change where to save exported files by selecting a folder in the option `Select output folder` as seen in the `Exporting data to Excel` frame in Figure 1. If the user selects another output folder than `Export`, only exported questionnaire data is placed there. Validation and data reports will still be saved to the log sub-folder `Log`.

1.3.4 Viewing modes

When any data is exported, they are exported based on two viewing modes, an `Edit` and a `Read only` mode.

`Edit` **mode** allows users to edit the data, comments and inclusions in the Excel sheet and reinsert them to the database as shown in Importing questionnaire to the database section. This works by preserving the table locations exactly where they are in the original questionnaire. Users will notice that created Excel workbooks look very similar to the original questionnaire. **do not move tables from their original locations, reorder or change names of administrative divisions, change the sheet**

names, or delete any of the data in the configuration panel; in the top left corner as seen in Figure 2. You are only allowed to modify cell figures, comments and inclusions. The configuration panel is necessary to reinsert the data, without it the validation would fail and modifying it might harm the functionality of the software.

`Read only` **mode** facilitates the viewing of the data by shifting tables to the left part of the Excel worksheet to avoid unnecessary scrolling. However, the mode will **not allow users to reinsert the data** back in the database, since the tables or alphanumeric codes are not in the exact location as they are in the original questionnaire. If users attempt to import a `Read only` mode file, the validation step will fail, hence not allowed to import.

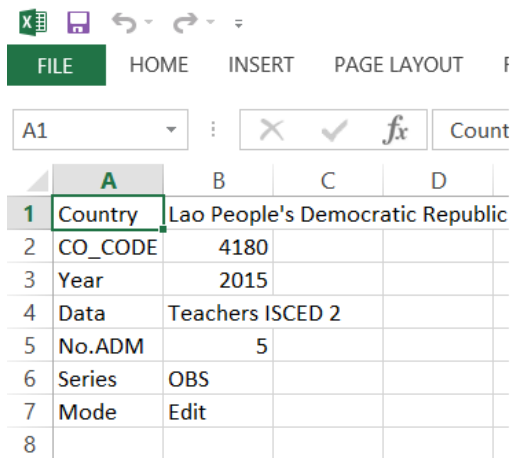


Figure 2: Screen shot of the top left corner of an exported Excel sheet which shows the configuration panel.

Important

- The viewing mode is chosen by the software. It is set to `Edit` mode if a sheet or the whole questionnaire is exported, otherwise it is set to `Read only` mode. Users can know the mode by looking at the configuration panel in any Excel sheet as seen in Figure 2.
- Users are only allowed to select from the drop-down list, or type manually the names of sheets, tables or ACs. If the users types anything else, the software will reject it.

1.3.5 Exporting and calculating indicators

Before exporting any indicators, we need to calculate them. For the selected country and year the `Calculate` button in the indicator sub-frame will calculate all indicators from the data in the *Estimated* series. Therefore, users must make sure that data exist in the *Estimated* series. Once all indicators are calculated, users can extract them using one of the following methods

Direct Extraction By selecting from the drop-down list or typing the indicator name (IND_ID) and clicking on the adjacent `Extract` button. To extract all indicators select or type `All`.

Wildcard Since the huge list of indicators, users can extract groups of indicators using name patterns, where `%` substitutes for zero or more characters and `_` substitutes for a single character. For example,

- to extract all indicators for teachers of ISCED 1 in the public sector you can type `%T.1.Pu%`, since all requested indicators have the pattern `T.1.Pu` in their name.
- to extract all the percentage of teachers with ISCED 2 or less qualification in all ISCED levels, type `EA2m%`, since all of them start with the pattern `EA2m`. If the interest is in the public sector only, type `EA2m%.Pu`.
- to extract the percentage of female teachers in ISCED levels 1, 2, and 3, but not 2 and 3, type `FT._`, since all have the pattern `FT.` in their name and `_` substitutes for a single character.

Note that wildcards are only applicable to indicator extraction, not raw data.

Note

- Similar to the extraction of raw data, indicators are extracted for the selected country and year, for all administrative divisions. Thus even if you select a single indicator to extract, the result is a table of one column and a number of rows corresponding to the number of administrative division plus the national level.
- Some indicators, for example the max and min of an indicator, is only calculated for the national level, nonetheless, the extraction would result in a table of 1 column and all the administrative division cells are empty, while the national level holds the indicator figure.
- If indicators are incalculable because of missing data or inclusions, the figure will be replaces by resulting magnitude code in the respective cell. **If the cell is empty, either the indicator is a national level indicator or the *Estimated* series is empty.**
- Indicators are always sorted alphabetically.
- Exported indicator file follow the naming convention `County Name-Year-Indic-indicator name.xlsx`, when the use of wildcards, `%` is replaced with `xx`.

For the current version of the software, these are the list of calculated indicators:

- Percentage of female teachers
- Percentage of newly recruited teachers
- Pupils teachers ratio
- Percentage of trained teachers
- Percentage of private teachers
- Percentage of non-permanent teachers
- Attrition rate
- Mean age
- Mean years of experience
- Highest level of educational attainment
- Percentage of teachers by years of experience
- Percentage of teachers by age
- Dissimilarity

For more details about the computational methods refer to Indicators section.

1.4 Validation report

A validation report is created and saved in the `Log` sub-folder every time the user attempts to insert a questionnaire by clicking on the `Validate` button. It includes all confirmations and errors and have the naming convention as `RM-Country Name-Year-Series-Data-Type-Time-Date.txt`.

The idea of the validation is to list critical errors with the selected file. Only if all the validation checks pass the questionnaire is then allowed to be inserted.

The validation check the below conditions, all failed conditions are saved and also printed to the Status panel:

1. If the insert is in the original questionnaire format
   - ADM label, i.e., Province, district etc, is filled.
   - number of ADM is a positive integer.
   - the ADM names are filled.
   - the correct number of sheets are available with correct original names.
   - reference year is filled and an integer, from cell `M14` in "Policy information" sheet.
   - Any "No" in the "checking sheet" is copied to the validation report.
2. If the insert is **not** in the original questionnaire format
   - worksheet must be in `Edit` mode.
   - configuration panel is properly filled.
     - no missing information.
     - labels of configuration are in the proper order of `[Country, CO_CODE, Year, Data, No.ADM, Series,Mode]`.
     - mode defined as "Edit".
     - year is an integer bigger than zero.
     - series is one of the following `[OBS,REP,EST]`.
     - country code matches the one taken from the database using the provided country name.
     - number of ADM is a positive integer. Note this variable is taken from the configuration panel, thus **do not change it.**
3. General checks:
   - check that all data values are either a number, inclusion (X), Z,z,A,a,N,n,M or m. Otherwise, validation fails and error is printed.

For more technical information, see Preprocessing section.

1.5 Data report

At this step if the validation checks have passed, once the user clicks on the `Insert` button, a data report is created and saved in the `Log` folder. If the checkbox `Open data report` is ticked, the report will automatically open. Also users can invoke the creation of a data report without validating or inserting the file, by clicking on the `Check only` button.

The data report check the following and lists any issues:

1. If the insertion is in the original questionnaire format
    - if ADM names exists in database they must equal the ones in the questionnaire, otherwise prints an error. This mean you can only change ADM names after they have been created by accessing the database directly, and if you try to reinsert the original questionnaire with reordered or changed region names, it will fail.
2. General
    - all columns must sum to the national level total
    - all sub-category must sum to the total. For example, public and private data must sum to the total.
    - all partial category data must be less than or equal to totals. For example, female data must be less than or equal to total.

Note, for all the cells that have missing data (m), inclusion (x), or inapplicable (z), the inequality or sums tests are ignored.

For more technical information, see Preprocessing section.

1.6 Audit trail

To keep track of changes to individual data and indicators, including figures, qualifiers, inclusion codes, and magnitudes, we have implemented an audit functionality in the backend (SQL), that records any changes to the data. This doesn't include data comments or table comments. We call this functionality **Audit trail**. Note that Audit trail tables are not accessible from the software interface (GUI), rather they function in the backend and only accessible by directly accessing the SQL database.

There are two main tables that keep track of changes, one for raw (meter) data called `METER_AUDIT_TRAIL`, and the other for indicators called `INDICATOR_AUDIT_TRAIL`. Their structure is very similar and could be combined in one table, nevertheless, for more clarity we separated the indicators from raw data.

In essence, every time there is a change in a data, both the old and new information is recorded with a timestamp and user name. The following two subsections discuss in more details how changes are recorded and how to understand and read these SQL tables.

1.6.1 Data audit trail

`METER_AUDIT_TRAIL` is the SQL table that records changes in raw data and metadata. Basically, any time there is a change in a raw figure or its metadata, which includes magnitudes (inclusion, missing,..) and qualifiers, both the new and old figures and metadata are recorded with the change timestamp and the user name. This change happens in the cleaning process, when the user attempts to modify data directly

in Excel and reinserts it into SQL. Thus every time an `Edit` mode excel file is validated and reinserted, the data is compared to what is in the SQL database, and any changes are recorded.

The following is the schema of the SQL table, where

- `MC_ID` is the numeric reference of the data and corresponds to an AC.
- `CO_CODE` is the country code.
- `ADM_CODE` is the administrative divisions code.
- `MC_YEAR` is the data year.
- `EM_FIG` is the actual data figure.
- `MQ_ID` is the data qualifier.
- `MG_ID` is the data magnitude.
- `SYS_DATA` is the internal local time to when the change has happened.

```
CREATE TABLE METER_AUDIT_TRAIL(
    Audit_ID Integer , -- auto-increment ID
    MC_ID decimal(6, 0) NOT NULL, --numeric reference of the data
    CO_CODE decimal(6, 0) NOT NULL, -- country code
    ADM_CODE INT NOT NULL, -- Administrative Division code.
    MC_YEAR decimal(4, 0) NOT NULL, -- data year
    EM_FIG_NEW varchar(4000) NULL, -- new figure
    EM_FIG_OLD varchar(4000) NULL,  -- old figure
    MQ_ID_NEW char(1) NULL, -- new qualifier
    MQ_ID_OLD char(1) NULL, -- old qualifier
    MG_ID_NEW char(1) NULL, -- new magnitude
    MG_ID_OLD char(1) NULL, -- old magnitude
    TYPE_MOD char(1) NULL,
    USER_NAME varchar(20) NOT NULL, -- user name
    SYS_DATE datetime DEFAULT (datetime('now','localtime')), --local timestamp
    SERIES varchar(10) NOT NULL, -- data series
    SURVEY_ID char(2) NULL, --- Regional model default is set to 'RM'
    PRIMARY KEY (Audit_ID ASC));
```

To read from the table, using `sqlite3` connect to `Prod.db` file or any other database file you are using and follow standard SQL extraction syntax as

```
SELECT * from METER_AUDIT_TRAIL LIMIT 5;
```

to see the first 5 rows of the table, and

```
SELECT a.* from METER_AUDIT_TRAIL AS a
LEFT JOIN EDU_METER_AID AS b ON a.MC_ID = b.EMC_ID
WHERE b.AC ='NT.1' AND a.CO_CODE = 4180 AND a.MC_YEAR = 2014;
```

for all the changes that happened to `NT.1`, newly recruited teachers in ISCED 1, initial education, for country with code 4180 for data year 2014. Using the `EDU_METER_AID` facilitates the use of AC directly rather than the numeric representation (`MC_ID`).

1.6.2 Indicator audit trail

`INDICATOR_AUDIT_TRAIL` is the SQL table that records changes in indicators and their metadata. Any time there is a change in the indicator or its metadata, which includes magnitudes (inclusion, missing,..) and qualifiers, both the new and old figures and metadata are recorded with change timestamp and the user name. This change happens when the user changes raw data and recalculates indicators by clicking on `Calculate` button in the indicator frame. Contrary to the data audit trail, users cannot manually change indicators and reinserts them, this functionality is not supported by the software.

The following is the schema of the SQL table, where

- `IND_ID` is the alphanumeric name of the indicator.
- `CO_CODE` is the country code.
- `ADM_CODE` is the administrative divisions code.
- `IND_YEAR` is the indicator data year.
- `FIG` is the actual indicator figure.
- `QUAL` is the indicator qualifier.
- `MAGN` is the indicator magnitude.
- `SYS_DATA` is the internal local time to when the change has happened.
- `SERIES` is always set to `EST` since indicators are only calculated from estimated series.

```
CREATE TABLE INDICATOR_AUDIT_TRAIL(
        Audit_ID Integer , -- auto-increment ID
        IND_ID varchar(50) NOT NULL, -- indicator ID
    CO_CODE decimal(6, 0) NOT NULL, -- country code
    ADM_CODE INT NOT NULL, -- Administrative Division code.
        IND_YEAR decimal(4, 0) NOT NULL, -- indicator data year
        FIG_NEW varchar(4000) NULL, -- new figure
        FIG_OLD varchar(4000) NULL, -- old figure
        QUAL_NEW char(1) NULL,  -- new qualifier
        QUAL_OLD char(1) NULL,  -- old qualifier
        MAGN_NEW char(1) NULL,  -- new magnitude
        MAGN_OLD char(1) NULL,  -- old magnitude
        USER_NAME varchar(20) NOT NULL,
        SYS_DATE datetime DEFAULT (datetime('now','localtime')), -- local change time
        SERIES varchar(10) NOT NULL, -- series is always EST
    PRIMARY KEY (Audit_ID ASC));
```

To read from the table, using `sqlite3` connect to `Prod.db` file or any other database file you are using and follow standard SQL extraction syntax as

```
SELECT * from INDICATOR_AUDIT_TRAIL LIMIT 5;
```

to see the first 5 rows of the table, and

```
SELECT * from INDICATOR_AUDIT_TRAIL
WHERE IND_ID ='FTP.1' AND CO_CODE = 4180 AND IND_YEAR = 2014;
```

for all the changes that happened to `FTP.1`, percentage of female teachers in ISCED 1, for country with code 4180 for data year 2014. Here we didn't need an `EDU_METER_AID` table sine indicators are referenced

directly by their alphanumeric code, which do not have an equivalent numerical representation like in raw data.

1.7 A complete example

1.7.1 Inserting the original questionnaire

To give an example consider inserting a made-up questionnaire say for Laos for year 2015 that is saved in a file `Desktop/Example/LAOS-2015-Regional_Survey.xlsx`, as seen in Figure 3. First start the `RM_GUI.py` select the file and click the adjacent `Validate`, the Status panel frame now shows:

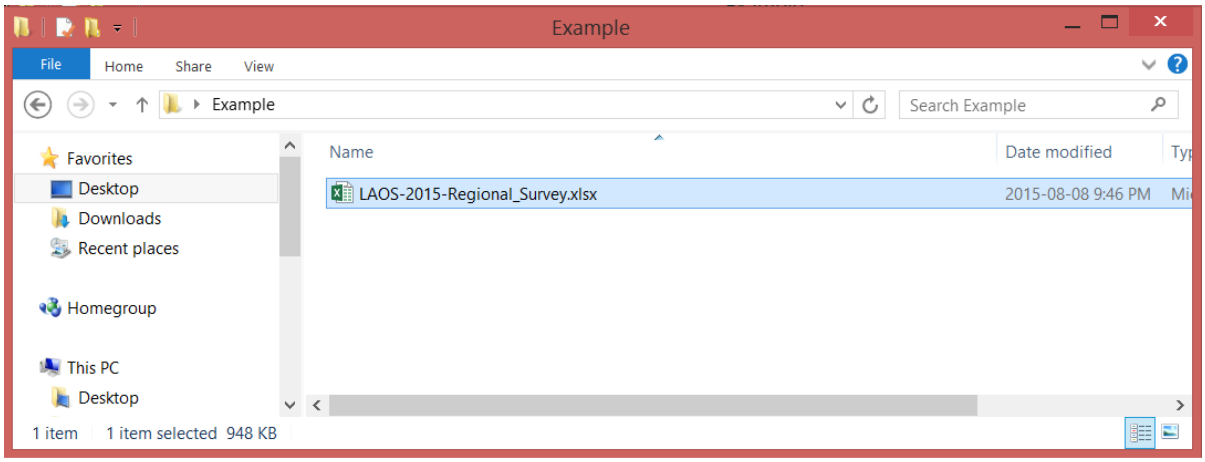


Figure 3: Laos original questionnaire submission.

```
----------Date: January 22, 2016----------
VALIDATION STEP

Original questionnaire submitted with path:
C:/Users/Mohamad/Desktop/Example/LAOS-2015-Regional_Survey.xlsx

Number of administrative divisions: 5.0
ADM1 name provided: District
Administrative divisions:
                  myDistrict 1
                  myDistrict 2
                  myDistrict 3
                  myDistrict 4
                  myDistrict 5

Reference year: 2015
Country name is filled: Lao People's Democratic Republic
The correct number of sheets(11)has been submitted.
Warning: The questionnaire contains missing values.

----------Questionnaire Validation finished.----------.

Validation successful, see report in:
Log/Lao People's Democratic Republic_16-01-22-13-32_validation.txt
```

Since the checkbox `Open validation report` is ticked a validation report should open and how more or less similarly output to the one in the Status panel.

To insert the questionnaire, click on `Insert`. The Status panel should show:

```
INSERTION STEP

Inserting C:/Users/Mohamad/Desktop/Example/LAOS-2015-Regional_Survey.xlsx
Checking that region values add to the country value...Test passed.
Checking that parts are less than the totals...Test passed.
Checking sums of columns...
----------Questionnaire Insertion finished.----------.

Data report written to:
 Log/Lao People's Democratic Republic_16-01-22-13-35_data_report.csv
```

Moreover, since the checkbox `Open data report` is ticked, the data report should open up. For this example, the data report looks like Figure 4

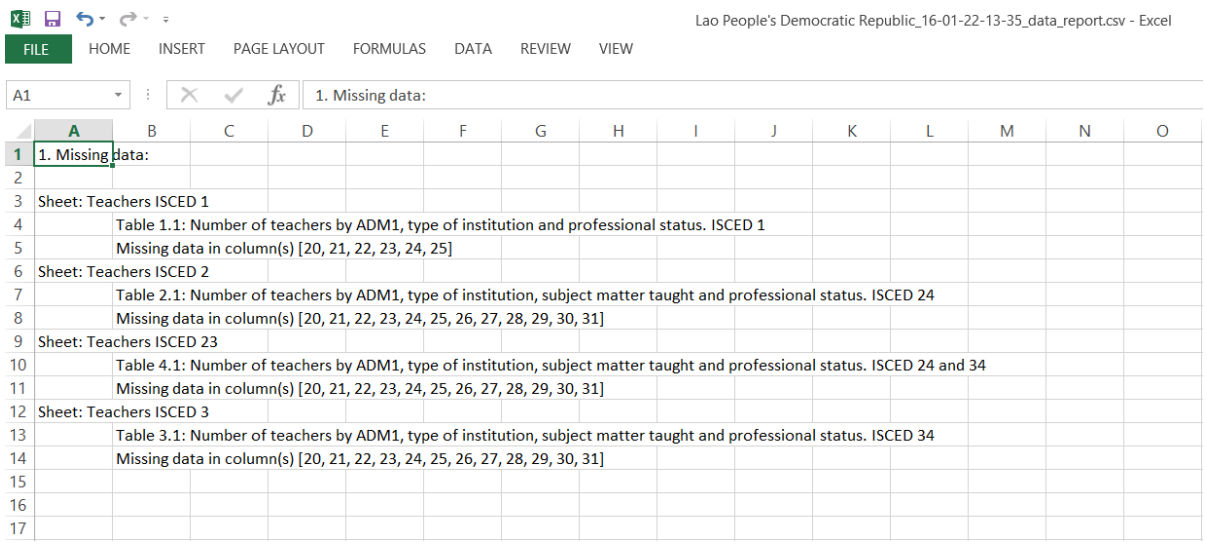


Figure 4: Laos data report after insertion

This implies the import is successfully, and these are the created files:

- **backup file**: `RMS\Import\RM_Lao People's Democratic Republic_2015_16-01-22-13-38.xlsx`,
- **validation file**: `RMS\Log\Lao People's Democratic Republic_16-01-22-13-38_validation.txt`,
- **data report**: `RMS\Log\Lao People's Democratic Republic_16-01-22-13-38_data_report.csv`.

1.7.2 Moving to and exporting from the Observed series.

After successfully inserting an original questionnaire, one is advised to move the data from *Reported* to *Observed* series. Notice that Laos now appears in the `Country` drop-down list. Select Laos and the corresponding year, then click on `REP to OBS` button. The Status panel should show

```
Moving data for 4180-2015
Moved METER, INCLU and FTN tables from REP to OBS
Moved COMMENT_TABLE table from REP to OBS
Done.
```

The `METER` table is where the data is, `INCLU` table is where the inclusion codes are saved, and `FTN` is where the cell comments are saved. Finally, `COMMENT_TABLE` is where the table comments are saved.

Now, let's export `Teachers ISCED 2` worksheet for cleaning. Select the country, year and series from the drop-down lists and from the `Sheet` drop-down list select `Teachers ISCED 2`. Before clicking on the adjacent `Export` button, select the `output folder` to be your `Desktop`.

The Status panel will have the confirmation seen in box 5, and the Excel workbook should look like `this`. Notice the configurations panel in the top left corner, where the mode is `Edit` and the series is `OBS`.

```
Exporting Teachers ISCED 2 from OBS series for
Lao People's Democratic Republic-2015....
File C:/Users/myUser/Desktop/Example/Lao People's Democratic Republic_2015_Teachers ISCED 2_OBS.xlsx is cr
Done.
```

Figure 5: Status frame output

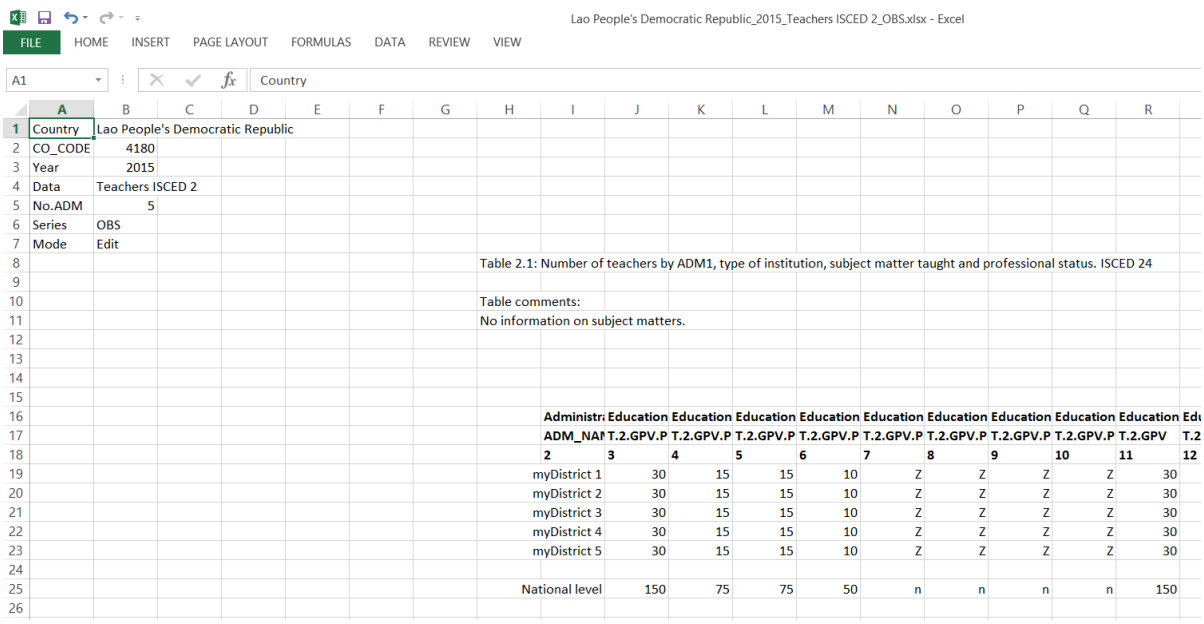


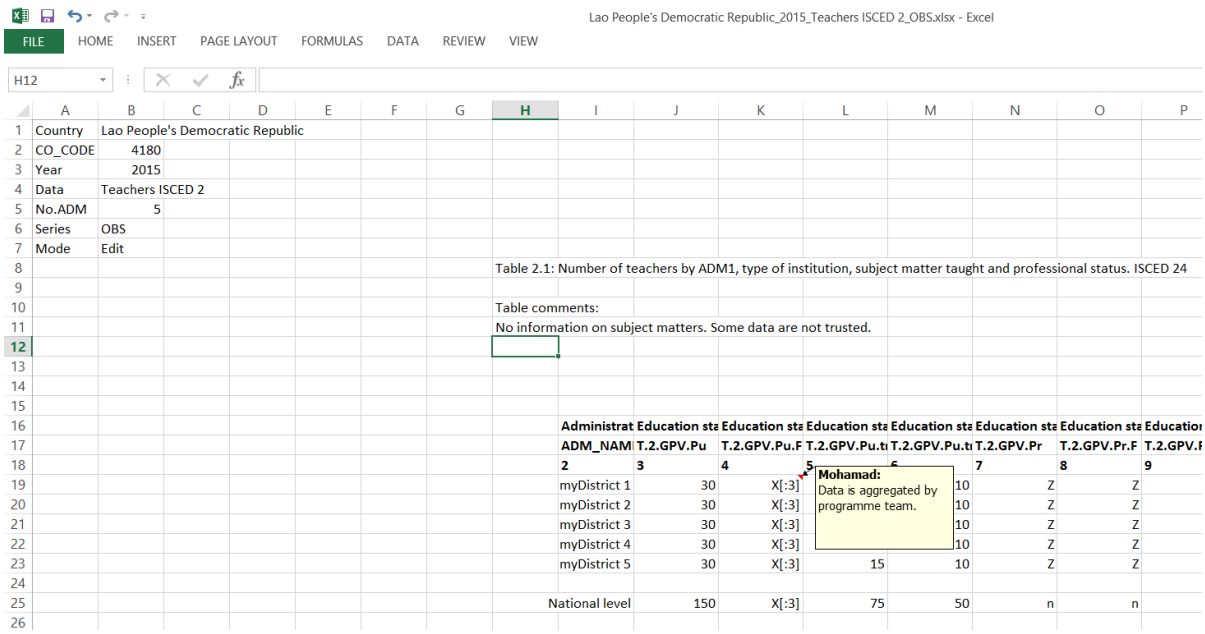
Figure 6: Exported Laos data from observed series.

1.7.3 Cleaning and reinserting

As mentioned before as long as the configuration panel is left untouched and all tables are not moved, one can go ahead and change the data, inclusion codes and insert cell and table comments. For example, assume for some reason, for Laos-2015 data, we prefer to only report the data under `T.2.GPV.Pu` in column 3 and not to report `T.2.GPV.Pu.F` in column 4. We do this by using inclusion code `X[:3]` to indicate that the current column is included in column 3.

Also we add a comment that the data is aggregated by programme team. Moreover, we add a table comment in cell H11, saying that some data is not trusted. See Figure 7 and compare it to Figure 6. Save and close the file.

To validate and insert follow similar step as in Section 1.2. Start the `RM_GUI` select the modified file, validate and insert it. If successful the Status panel should show



Lao People's Democratic Republic_2015_Teachers ISCED 2_OBS.xlsx - Excel

FILE HOME INSERT PAGE LAYOUT FORMULAS DATA REVIEW VIEW

H12

	A	B
1	Country	Lao People's Democratic Republic
2	CO_CODE	4180
3	Year	2015
4	Data	Teachers ISCED 2
5	No.ADM	5
6	Series	OBS
7	Mode	Edit

Table 2.1: Number of teachers by ADM1, type of institution, subject matter taught and professional status. ISCED 24

Table comments:
No information on subject matters. Some data are not trusted.

	Administrat	Education sta	Education sta	Education sta	Education sta	Education sta	Education sta	Educatio
	ADM_NAM	T.2.GPV.Pu	T.2.GPV.Pu.F	T.2.GPV.Pu.ti	T.2.GPV.Pu.ti	T.2.GPV.Pr	T.2.GPV.Pr.F	T.2.GPV.F
	2	3	4	5	6	7	8	9
19	myDistrict 1	30	X[:3]		10	Z	Z	
20	myDistrict 2	30	X[:3]		10	Z	Z	
21	myDistrict 3	30	X[:3]		10	Z	Z	
22	myDistrict 4	30	X[:3]		10	Z	Z	
23	myDistrict 5	30	X[:3]	15	10	Z	Z	
25	National level	150	X[:3]	75	50	n	n	

Mohamad:
Data is aggregated by programme team.

Figure 7: Modified Laos data from observed series.

```
----------Date: January 22, 2016----------
VALIDATION STEP

Edited questionnaire submitted with path:
C:/Users/Mohamad/Desktop/Example
/Lao People's Democratic Republic_2015_Teachers ISCED 2_OBS.xlsx

Number of administrative divisions: 5.0
Configuration section of edited questionnaire is properly filled
Warning: The questionnaire contains missing values.

----------Questionnaire Validation finished.----------.

Validation successful, see report in:
Log/Lao People's Democratic Republic_16-01-22-21-23_validation.txt
----------Date: January 22, 2016----------
INSERTION STEP

Inserting C:/Users/Mohamad/Desktop/Example/
        Lao People's Democratic Republic_2015_Teachers ISCED 2_OBS.xlsx
Checking that region values add to the country value...Test passed.
Checking that parts are less than the totals...Test passed.
Checking sums of columns...Test passed.
----------Questionnaire Insertion finished.----------.

Data report written to:
 Log/Lao People's Democratic Republic_16-01-22-21-23_data_report.csv
```

otherwise it would list validation errors such as.

```
----------Date: January 22, 2016----------
VALIDATION STEP

Edited questionnaire submitted with path:
C:/Users/Mohamad/Desktop/Example
/Lao People's Democratic Republic_2015_Teachers ISCED 2_OBS.xlsx

Number of administrative divisions: 5.0
Configuration section of edited questionnaire is properly filled
Error: Column 3 in table Table 2.1 has improper values.
Warning: The questionnaire contains missing values.

----------Questionnaire Validation finished.----------.

Pre-processing validation failed. Some errors exist see log file in:
Log/Lao People's Democratic Republic_16-01-22-21-25_validation.txt
```

Since inserting is successful, again, the following files are created:

- **backup file**: `RMS\Import\RM_Lao People's Democratic Republic_2015_16-01-22-21-23.xlsx`,
- **validation report**: `RMS\Log\Lao People's Democratic Republic_16-01-22-21-23_validation.txt`,
- **data report**: `RMS\Log\Lao People's Democratic Republic_16-01-22-21-23_data_report.csv`.

Now if you reexport the whole questionnaire, `Teachers ISCED 2` sheet, or only `Table 2.1` from the observed series, you should be able to see the changes and comments made earlier.

1.7.4 Calculating indicators

To calculate indicators, first select the country name and year, then select the `EST` series. If the data is not yet in the `EST` series, move it by clicking on the button `OBS to EST`, maybe also `REP to OBS` if you haven't moved it yet to `OBS` series. Then click on the button `Calculate`. In around **30 seconds to a minutes**, the Status panel should indicated that the process is successful.

```
Successful..all indicators are calculated.
```

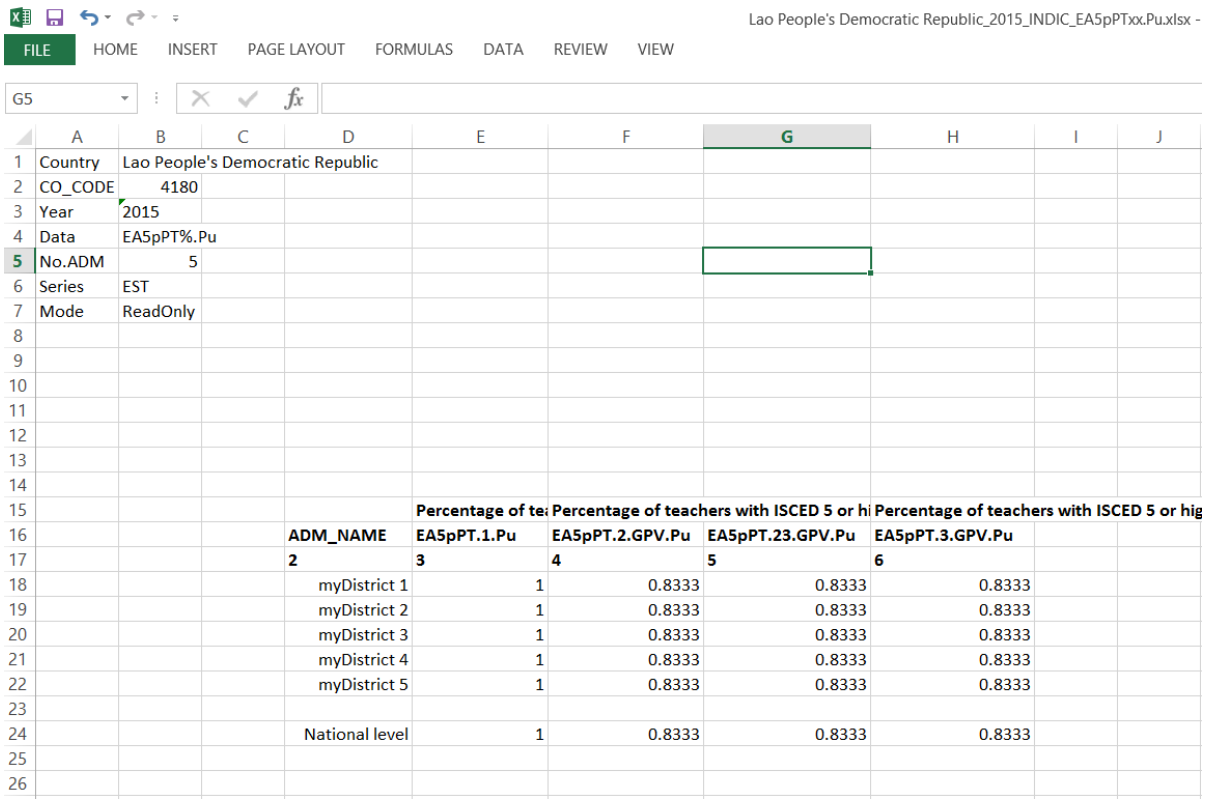
Now using the wildcards, lets extract the percentage of teachers with attainment of ISCED 5 and higher for all public institutions, one way of doing this by typing `EA5pPT.%Pu` and clicking on the adjacent `Extract`. The file is now saved under the name `Lao People's Democratic Republic_2015_INDIC_EA5pPT.xxPu.xlsx` in the `Export` folder if no other folder is specified. This is indicated in the Status panel as seen below.

```
Extracting EA5pPT.%Pu for Lao People's Democratic Republic-2015....
File /home/mo/Desktop/Lao People's Democratic Republic_2015_INDIC_EA5pPT.xxPu.xlsx is created..
Done.
```

The file should also automatically open up and in this example it looks like this.

2 Indicators

This section describs how the indicators are computed and what are the AC codes involved in their computation. For each indicator, we give a table with four columns. The first column has the ISCED level. The second one has the indicator alphanumeric code (IND_ID) used for the indicator. The third



Lao People's Democratic Republic_2015_INDIC_EA5pPTxx.Pu.xlsx -

	A	B	C	D	E	F	G	H	I	J
1	Country	Lao People's Democratic Republic								
2	CO_CODE	4180								
3	Year	2015								
4	Data	EA5pPT%.Pu								
5	No.ADM	5								
6	Series	EST								
7	Mode	ReadOnly								
8										
9										
10										
11										
12										
13										
14										
15					Percentage of te	Percentage of teachers with ISCED 5 or hi		Percentage of teachers with ISCED 5 or hig		
16				ADM_NAME	EA5pPT.1.Pu	EA5pPT.2.GPV.Pu	EA5pPT.23.GPV.Pu	EA5pPT.3.GPV.Pu		
17				2	3	4	5	6		
18				myDistrict 1	1	0.8333	0.8333	0.8333		
19				myDistrict 2	1	0.8333	0.8333	0.8333		
20				myDistrict 3	1	0.8333	0.8333	0.8333		
21				myDistrict 4	1	0.8333	0.8333	0.8333		
22				myDistrict 5	1	0.8333	0.8333	0.8333		
23										
24				National level	1	0.8333	0.8333	0.8333		
25										
26										

Figure 8: Screen shot of EA5pPT indicator

column has the formula used to compute this indicator. The fourth column contains yes or no depending on whether the indicator for the highest and lowest among administrative divisions is also calculated.

Technical notations used across the document:

- The `Python method` lists the name of function in the `Libraries/rmindicators.py` script that calculates that indicator.
- The superscript `L`, means that the value from the previous year is being taken. For example, if the emco year is 2015 $T.1^{L}$ means that the 2014 value of T.1.
- Some indicators correspond to the highest and lowest value among all the regions of some indicator; A.Max and A.Min correspond to the highest and lowest value, respectively, among all the regions for the AC code A. The fourth column of each indicators says if there is also a highest and lowest indicator.

Some more specific technical notation exists for some of the subsections.

2.1 Percentage of female teachers

Python method teachers_percentage_female

IND_IDS information

	IND_ID	FORMULA	H & L
ISCED 1	FTP.1	NT.1.F/T.1	yes
ISCED 2	FTP.2	NT.2.GPV/T.2.GPV	yes
ISCED 3	FTP.3	NT.3.GPV/T.3.GPV	yes
ISCED 23	FTP.2t3	NT.23.GPV/T.23.GPV	yes

2.2 Percentage of newly recruited teachers

Python method newly_recruited_teachers

IND_IDS information

	IND_ID	FORMULA	H & L
ISCED 1	NTP.1	NT.1/T.1	no
ISCED 2	NTP.2	NT.2.GPV/T.2.GPV	no
ISCED 3	NTP.3	NT.3.GPV/T.3.GPV	no
ISCED 23	NTP.2t3	NT.23.GPV/T.23.GPV	no

2.3 Pupils teachers ratio

Python method pupils_teachers_ratio

IND_IDS information

	IND_ID	FORMULA	H & L
ISCED 1	PTRHC.1	E.1/T.1	yes
ISCED 2	PTRHC.2	E.2.GPV/T.2.GPV	yes
ISCED 3	PTRHC.3	E.3.GPV/T.3.GPV	yes
ISCED 23	PTRHC.2t3	E.23.GPV/T.23.GPV	yes

2.4 Percentage of trained teachers

Python method percentage_trained_teachers

IND_IDS information

	IND_ID	FORMULA	H & L
ISCED 1	TRTP.1	T.1.trained/T.1	yes
ISCED 2	TRTP.2	T.2.GPV.trained/T.2.GPV	yes
ISCED 3	TRTP.3	T.3.GPV.trained/T.3.GPV	yes
ISCED 23	TRTP.2t3	T.23.GPV.trained/T.23.GPV	yes

In this same method, there is the computation of the percentage of trained newly recruited teachers, which has the following table

	IND_ID	FORMULA	H & L
ISCED 1	TrNTP.1	NT.1.trained/NT.1	yes
ISCED 2	TrNTP.2	NT.2.GPV.trained/NT.2.GPV	yes
ISCED 3	TrNTP.3	NT.3.GPV.trained/NT.3.GPV	yes
ISCED 23	TrNTP.2t3	NT.23.GPV.trained/NT.23.GPV	yes

2.5 Percentage of private teachers

Python method percentage_private_teachers

IND_IDS information

	IND_ID	FORMULA	H & L
ISCED 1	PrTP.1	T.1.Pr/T.1	yes
ISCED 2	PrTP.2	T.2.GPV.Pr/T.2.GPV	yes
ISCED 3	PrTP.3	T.3.GPV.Pr/T.3.GPV	yes
ISCED 23	PrTP.2t3	T.23.GPV.Pr/T.23.GPV	yes

2.6 Percentage of non-permanent teachers

This has three sets of symbols. One for the private sector, one for the public sector and one combined.

Python method percentage_non_permanent_teachers

IND_IDS information Private

	IND_ID	FORMULA	H & L
ISCED 1	FixTP.1.Pr	T.1.Pr.Fix/T.1.Pr	no
ISCED 2	FixTP.2.GPV.Pr	T.2.GPV.Pr.Fix/T.2.GPV.Pr	no
ISCED 3	FixTP.3.GPV.Pr	T.3.GPV.Pr.Fix/T.3.GPV.Pr	no
ISCED 23	FixTP.2t3.GPV.Pr	T.23.GPV.Pr.Fix/T.23.GPV.Pr	no

IND_IDS information Public

	IND_ID	FORMULA	H & L
ISCED 1	FixTP.1.Pu	T.1.Pu.Fix/T.1.Pu	no
ISCED 2	FixTP.2.GPV.Pu	T.2.GPV.Pu.Fix/T.2.GPV.Pu	no
ISCED 3	FixTP.3.GPV.Pu	T.3.GPV.Pu.Fix/T.3.GPV.Pu	no
ISCED 23	FixTP.2t3.GPV.Pu	T.23.GPV.Pu.Fix/T.23.GPV.Pu	no

IND_IDS information Combined

	IND_ID	FORMULA	H & L
ISCED 1	FixTP.1	(T.1.Pr.Fix+T.1.Pu.Fix)/(T.1.Pr+T.1.Pu)	no
ISCED 2	FixTP.2.GPV	(T.2.GPV.Pr.Fix+T.2.GPV.Pu.Fix)/(T.2.GPV.Pr+T.2.GPV.Pu)	no
ISCED 3	FixTP.3.GPV	(T.3.GPV.Pu.Fix+T.3.GPV.Pr.Fix)/(T.3.GPV.Pr+T.3.GPV.Pu)	no
ISCED 23	FixTP.2t3.GPV	(T.23.GPV.Pu.Fix+T.23.GPV.Pr.Fix)/(T.23.GPV.Pr+T.23.GPV.Pu)	no

2.7 Attrition rate

Python method percentage_non_permanent_teachers

IND_IDS information Private

	IND_ID	FORMULA	H & L
ISCED 1	TAttrR.1	100*(T.1^{L} + NT.1 - T.1)/T.1^{L}	no
ISCED 2	TAttrR.2.GPV	100*(T.2.GPV^{L} + NT.2.GPV - T.2.GPV)/T.2.GPV^{L}	no
ISCED 3	TAttrR.3.GPV	100*(T.3.GPV^{L} + NT.3.GPV - T.3.GPV)/T.3.GPV^{L}	no
ISCED 23	TAttrR.2t3.GPV	100*(T.23.GPV^{L} + NT.23.GPV - T.23.GPV)/T.23.GPV^{L}	no

2.8 Mean age

Python method mean_age_level(level in ['T.1', 'T.2.GPV', 'T.3.GPV', 'T.23.GPV'])

IND_IDS information

	IND_ID	FORMULA	H & L
ISCED 1	MAge.T.1	$\sum_{\text{y in cat}}$ T.1.y × MP.y / $\sum_{\text{y in cat}}$ T.1.y	No
ISCED 2	MAge.T.2.GPV	$\sum_{\text{y in cat}}$ T.2.GPV.y × MP.y/ $\sum_{\text{y in cat}}$ T.2.GPV.y	No
ISCED 3	MAge.T.3.GPV	$\sum_{\text{y in cat}}$ T.3.GPV.y × MP.y/$\sum_{\text{y in cat}}$ T.3.GPV.y	No
ISCED 23	MAge.T.23.GPV	$\sum_{\text{y in cat}}$ T.23.GPV.y× MP.y/ $\sum_{\text{y in cat}}$ T.23.GPV.y	No

where `cat` is `Ag20m`, `Ag20t29`, `Ag30t39`, `Ag40t49`, `Ag50t59` and `Ag60p`. Midpoints (MP) are based on the following:

Age in years	<20	20-29	30-39	40-49	50-59	60+
Midpoints	20	24.5	34.5	44.5	54.5	60

Note all indicators are calculated for Total, Public and Private levels.

2.9 Mean years of experience

Python method mean_exp_level(level in ['T.1', 'T.2.GPV', 'T.3.GPV', 'T.23.GPV'])

IND_IDS information

	IND_ID	FORMULA	H & L
ISCED 1	MExp.T.1	$\sum_{\text{y in cat}}$ T.1.y × × MP.y/ $\sum_{\text{y in cat}}$ T.1.y	No
ISCED 2	MExp.T.2.GPV	$\sum_{\text{y in cat}}$ T.2.GPV.y× MP.y / $\sum_{\text{y in cat}}$ T.2.GPV.y	No
ISCED 3	MExp.T.3.GPV	$\sum_{\text{y in cat}}$ T.3.GPV.y× MP.y / $\sum_{\text{y in cat}}$ T.3.GPV.y	No
ISCED 23	MExp.T.23.GPV	$\sum_{\text{y in cat}}$ T.23.GPV.y× MP.y / $\sum_{\text{y in cat}}$ T.23.GPV.y	No

where `cat` is `Exp1t2`, `Exp3t5`, `Exp6t10`, `Exp11t15` and `Exp15p`. and Midpoints (MP) are `MP` is `[Exp1t2 = 1.5, Exp3t5 = 4, Exp6t10 = 8, Exp11t15 = 13, Exp15p = 15]`. Midpoints are based on the following:

Experience in years	New	1-2	3-5	6-10	11-15	15+
Midpoints	0.5	1.5	4	8	13	17

Note all indicators are calculated for Total, Public and Private levels.

2.10 Highest level of educational attainment

Python method percentage_teachers_attainment

IND_IDS information

Highest educational attainment	IND_ID	FORMULA	H & L
Lower secondary or Less	EA.2mPT.IS	T.IS.EA.2m / T.IS	No
Upper secondary	EA.3PT.IS	T.IS.EA.3 / T.IS	No
Post secondary	EA.4PT.IS	T.IS.EA.4 / T.IS	No
At least tertiary	EA.5pPT.IS	T.IS.EA.5 + T.IS.EA.6+T.IS.EA.7+T.IS.EA.8/T.IS	No
Unknown	EA.ukPT.IS	T.IS.EA.uk / T.IS	No

`IS` stands for ISCED level which are `[1, 2.GPV, 3.GPV, 23.GPV]`, combined with suffixes `['.Pu', '.Pr']` for public and private sub-category.

Note all indicators are calculated for Total, Public and Private levels.

2.11 Percentage of teachers by years of experience

Python method percentage_teachers_exp

IND_IDS information

Experience	IND_ID	FORMULA	H & L
1 to 2 years	Exp1t2mPT.ISCED	T.ISCED.Exp1t2/T.ISCED	No
3 to 5 years	Exp3t5PT.ISCED	T.ISCED.Exp3t5/T.ISCED	No
5 to 10 years	Exp6t10PT.ISCED	T.ISCED.Exp6t10/T.ISCED	No
11 to 15 years	Exp11t15PT.ISCED	T.ISCED.Exp11t15/T.ISCED	No
more 15 than years	Exp15pPT.ISCED	T.ISCED.Exp15p/T.ISCED	No
Unknown	ExpukPT.ISCED	T.ISCED.Expuk/T.ISCED	No

`ISCED` is `[' 1', '2.GPV', '3.GPV', '23.GPV']`, combined with suffixes `['.Pu', '.Pr']` for public and private sub-category.

Note all indicators are calculated for Total, Public and Private levels.

2.12 Percentage of teachers by age

Python method percentage_teachers_age

IND_IDS information

Age	IND_ID	FORMULA	H & L
Less than 20 years	Ag20mPT.ISCED	T.ISCED.Ag20m/T.ISCED	No
20 to 29 years	Ag20t29PT.ISCED	T.ISCED.Ag29t29/T.ISCED	No
30 to 39 years	Ag30t39PT.ISCED	T.ISCED.Ag39t39/T.ISCED	No
40 to 49 years	Ag40t49PT.ISCED	T.ISCED.Ag49t49/T.ISCED	No
50 to 59 years	Ag50t59PT.ISCED	T.ISCED.Ag59t59/T.ISCED	No
60 years or more	Ag60pPT.ISCED	T.ISCED.Ag60P/T.ISCED	No
Unknown	AgukPT.ISCED	T.ISCED.Aguk/T.ISCED	No

`ISCED` is `[' 1', '2.GPV', '3.GPV', '23.GPV']`, combined with suffixes `['.Pu', '.Pr']` for public and private sub-category.

Note all indicators are calculated for Total, Public and Private levels.

2.13 Dissimilarity index

Python method dissimilarity_index

IND_IDS information

Measures of inequality in the	IND_ID	FORMULA
All	DIndT.IS	$\frac{1}{2}\sum_a \mid \frac{T.IS_a}{T.IS} - \frac{E.IS_a}{E.IS} \mid$
Female	DIndT.IS.F	$\frac{1}{2}\sum_a \mid \frac{T.IS.F_a}{T.IS.F} - \frac{E.IS_a}{E.IS} \mid$
Teachers aged 50 and above	DIndT.IS.Ag50p	$\frac{1}{2}\sum_a \mid \frac{T.IS.Ag50p_a}{T.IS.Ag50p} - \frac{E.IS_a}{E.IS} \mid$
Newly recruited	DIndNT.IS	$\frac{1}{2}\sum_a \mid \frac{NT.IS_a}{NT.IS} - \frac{E.IS_a}{E.IS} \mid$
Math	DIndT.IS.Math	$\frac{1}{2}\sum_a \mid \frac{T.IS.Math_a}{T.IS.Math} - \frac{E.IS_a}{E.IS} \mid$
Reading and writing	DIndT.IS.Read	$\frac{1}{2}\sum_a \mid \frac{T.IS.Read_a}{T.IS.Read} - \frac{E.IS_a}{E.IS} \mid$
Trained teachers	DIndT.IS.trained	$\frac{1}{2}\sum_a \mid \frac{T.IS.trained_a}{T.IS.trained} - \frac{E.IS_a}{E.IS} \mid$
Newly recruited and trained teachers	DIndNT.IS.trained	$\frac{1}{2}\sum_a \mid \frac{NT.IS.trained_a}{NT.IS.trained} - \frac{E.IS_a}{E.IS} \mid$
Teachers with ISCED level+1 or less	DIndT.IS.EA.ISp1m	$\frac{1}{2}\sum_a \mid \frac{T.IS.EA.ISp1m_a}{T.IS.EA.ISp1m} - \frac{E.IS_a}{E.IS} \mid$
Teachers with ISCED level+2 or more	DIndT.IS.EA.ISp2p	$\frac{1}{2}\sum_a \mid \frac{T.IS.EA.ISp2p_a}{T.IS.EA.ISp2p} - \frac{E.IS_a}{E.IS} \mid$
Teachers with less than 2 years of exp	DIndT.IS.Exp2m	$\frac{1}{2}\sum_a \mid \frac{T.IS.Exp2m_a}{T.IS.Exp2m} - \frac{E.IS_a}{E.IS} \mid$
Teachers with more than 10 years of exp	DIndT.IS.Exp10p	$\frac{1}{2}\sum_a \mid \frac{T.IS.Exp10p_a}{T.IS.Exp10p} - \frac{E.IS_a}{E.IS} \mid$
Private teachers	DIndT.IS.Pr	$\frac{1}{2}\sum_a \mid \frac{T.IS.Pr_a}{T.IS.Pr} - \frac{E.IS_a}{E.IS} \mid$
Non-permanent teachers, total	DIndT.IS.Fix	$\frac{1}{2}\sum_a \mid \frac{T.IS.Fix_a}{T.IS.Fix} - \frac{E.IS_a}{E.IS} \mid$
Non-permanent teachers, private	DIndT.IS.Pr.Fix	$\frac{1}{2}\sum_a \mid \frac{T.IS.Pr.Fix_a}{T.IS.Pr.Fix} - \frac{E.IS.Pr_a}{E.IS.Pr} \mid$
Non-permanent teachers, public	DIndT.IS.Pu.Fix	$\frac{1}{2}\sum_a \mid \frac{T.IS.Pu.Fix_a}{T.IS.Pu.Fix} - \frac{E.IS.Pu_a}{E.IS.Pu} \mid$

Much notations are omitted for clearer presentation.

- `IS` stands for ISCED level which are `[1, 2.GPV, 3.GPV, 23.GPV]`.
- `a` stands for administrative division, on the denominators the `a` is omitted for national level data.
- `E.23.GPV` is not collected in the questionnaire, so it `E.2.GPV + E.3.GPV`.
- To compute age 50 plus, data in ages 50 o 59 and 60 plus are added. This notation is omitted in the formula for brevity.
- Only calculated for ISCED level 2t3, total.
- `ISp1m` reads as ISCED level which is 1 level above or less than the actual level, that is for ISCED 2 `ISp1m = 3m`, and for ISCED 2t3 `ISp1m =3m`. The levels are summed.
- `ISp2p` reads as ISCED level which is 2 level above or more than the actual level, that is for ISCED 2 `ISp2p = 4pm`, and for ISCED 2t3 `ISp2p =5p`. The levels are summed.

3 Adding Indicators

3.1 The indicators class

To deal with indicator calculations, we have created a Python class that we named `indicators()`, it exists in the script `RMS/Libraries/rmindicators.py`. This indicators class has three types of methods, auxiliary, indicators and action methods.

The auxiliary methods are an aid either for the computation of indicators or for SQL interaction. Examples of these methods are: `get_nadm1`, `set_database_connection`, `get_country_code`, `column_operation`, `compute_percentages`.

The indicator methods, are methods that compute the value of an indicator and adds their values to the SQL database. Examples of these functions are: `pupils_teachers_ratio`, `newly_recruited_teachers`, `teachers_percentage_female`, `percentage_trained_teachers`, `percentage_private_teachers`, `percentage_non_p`

There are only two action methods: `__init__` and `compute_all_indicators`. The former is the initializer of the class and is called every time the class is initiated. The latter is a method that calls all the other indicators methods.

Without dwelling into much detials the objective of this section is to show how to program new indicators by using the methods of the `indicators` class.

3.2 Setup template

To program new indicators, we first need to create a method that computes the values of the indicator and writes those values to the database. Second, we need to add the new created method to `compute_all_indicators` method. At this point, the GUI will also compute this method when the `Calculate` button is clicked. The following is the current `compute_all_indicators` method, which shows the list of indicators that are calculated every time this method is called.

```
def compute_all_indicators(self):
        """ Excute functions to calculate indicators."""
        ### Moving data to Audit Temp
        self.audit_trail()

        ##### Calculating indicators
        self.pupils_teachers_ratio()
        self.newly_recruited_teachers()
        self.teachers_percentage_female()
        self.percentage_trained_teachers()
        self.percentage_private_teachers()
        self.attrition_rate()
        self.percentage_non_permanent_teachers()
        self.percentage_teachers_attainment()
        self.percentage_teachers_exp()
        self.percentage_teachers_age()
        self.mean_level(self.mean_exp_level)
        self.mean_level(self.mean_age_level)
        self.dissimilarity_index()

        ## Moving changed values to Audut trail
        self.audit_trail(False)
```

Before adding a method to the indicators class, we advise to test it in a different file without modifying the main code in `rmindicators.py`. Let's start with an example on how to do this. First, in a new script, import the `rmquestionnaire` library so we can use its methods. This can be achieved with the following code:

```
import sys, os

os.chdir(path_to_main_RMS_folder)
sys.path.append('Libraries')

from rmquestionnaire import *
```

by modifying the `path_to_main_RMS_folder` to your path to the main folder where `RMS` is installed, for example `/Desktop/RMS` if it is installed on your desktop. Second, create a test class that inherits all the methods in the `indicators` class, you can do this using the following code.

```
class tests_indicators(indicators):
```

Finally, use the SQL methods of class `indicators` to write to SQL. This could be done by `write_indic_sql`, which writes a dictionary of indicator values to SQL. The key of the dictionary is the indicator name, and the value of the dictionary is the indicators values. The following is a complete template that you can use by modifying the path to the main RMS directory and the indicator and function names.

```
 import sys, os
 os.chdir(path_to_main_RMS_folder)  # Path to main directory
 sys.path.append('Libraries')
 from rmquestionnaire import *

class tests_indicators(indicators):
     def function_indicator_name(self):
         # The following is a dictionary used for inserting the value in the database
         ind_dict={}
         indicator_name="MyIndicator"
         ### Start of indicator calculation method

         indicator_values= = ....... # attach indicator values to this variable
         ### End of indicator calculation method

         # We prepare a dictionary for the function write_indic_sql
         ind_dict[indicator_name]=indicator_values
         self.write_indic_sql(ind_dict)
```

At this point we are ready to program the new indicator method.

Let us say that we want to compute the proportion of teachers in public schools in ISCED1 that have one or two years of experience. Let us call this indicator "PT.1.Pu.Exp1t2". This would correspond to dividing "T.1.Pu.Exp1t2" by "T.1.Pu". The method `column_operation` is very handy in this case. Almost all the current indicators rely heavily on this function, therefore it deserves a discussion by itself.

3.3 Column operation

The function `column operation` applies a function to two columns in any of the tables of the RM questionnaire. Since all columns are indexed by an alphanumeric code (AC), it is sufficient to pass the ACs themselves and `column_operation` will extract all the region and national figures of these two ACs and preform an operation on each of the adjacent cells of these columns.

The `column_operation` has three arguments, the first two arguments have the form `[AC,year]`, where AC is an alphanumeric code and year is either 0 or -1. 0 stands for the value of the current year and -1 for the previous year. We only pass 0 or -1 rather than the complete year as 2014 or 2015, because by

initiating the indicator class, you need to pass to it the country name and year, thus it already knows this information. The third argument is a function of the following `sum`, `prod`, `div` and `neg` that compute the sum, multiplication, division and negation according to a specific set of rules that we call *algebras*. All these functions are seen in the first part of `Libraries/rmindicators.py` and are not the default Python operations. It is also possible to only pass the first argument. In this case the values that correspond to the alphanumeric code and year are returned.

To use any of the four mathematical operations, each takes two arguments of the form `[fig, symbol]` (it can be a list or a tupple). `symbol` has to be one of the following: 'a', 'm', 'n', 'x' or 'value' depending if the data is not applicable, missing, null, a reference or a number respectively. `fig` is the value to which the operation is going to be applied. The functions return a pair `[value, symbol]`, where value is the result of the function applied to the values received and symbol is the magnitude of this value. The objective of the algebra is to decide whether the operation should be preformed or the data is irregular. For example, when you attempt to sum two columns say, `E.1.Pu` and `E.1.Pr`, say that for one of the regions `E.1.Pu=10` while `E.1.Pr` is missing, what should be the value of the sum? We answer this question by constructing a table as shown below, where the upper left corner is the name of the operation, and each cell, excluding the row and column headers, corresponds to the resulting magnitude value when preforming the operation. For example, since `E.1.Pu=10` and say it doesn't include any other category, then its magnitude is `value`, while `E.1.Pr` has a magnitude of `m` for missing. Thus, the sum of `[10, '']` and `['', 'm']` would return `['', 'm']` as a null `fig` and a missing magnitude `symbol`, based on the table. The cell that corresponds to `value` and `m` is `m`.

Sum	a	m	n	x	value
a	a	a	a	a	a
m	a	m	m	m	m
n	a	m	n	m	value
x	a	m	m	m	m
value	a	m	value	m	value

In Python this looks like:

```
sum([10, 'value], ['', 'm']) = ['', 'm']
```

While if `E.1.Pr=5` then the cell that corresponds to `(value, value)` is also `value`, in this case the sum operation is preformed.

```
sum([10, 'value], [5, 'value']) = [15, 'value']
```

You can view these algebra rules in the following files:

- `RMS/Libraries/algebra-sum.csv` for the sum algebra as in the table above.
- `RMS/Libraries/algebra-prod.sv` for the product algebra.
- `RMS/Libraries/algebra-div.csv` for the division algebra as in the table above.

The negation algebra is the same as the sum algebra.

Important

The algebra files are read every time the `RM_GUI` is initiated, thus, if the user doesn't agree with the result of the algebra you can change it directly in the file. **Be careful** as the software might behave inappropriately if the algebra is set wrong. For example, when summing a numeric value with a non-numeric one.

Now to sum any two ACs, or columns, of the RM questionnaire, one can use the `column_operation` function directly as

```
column_operation(['E.1.Pr', 0], ['E.1.Pu', 0], sum)
```

This would return the sum of the each of the two adjacent cells of the columns, that is region by region.

3.4 Example

To get back to our example, we wanted to compute the proportion of teachers in public schools in ISCED1 that have one or two years of experience. Let us call this indicator "PT.1.Pu.Exp1t2". This would correspond to dividing "T.1.Pu.Exp1t2" by "T.1.Pu". To do so, we use the `column_operation` and `div` with the template provided in the end of 3.2 section.

We define the function name as `proportion_public_teachers_1t2exp_isced1(self)`, and the code looks like:

```
class tests_indicators(indicators):
    def proportion_public_teachers_1t2exp_isced1(self):
        # The following is a dictionary used for inserting the value in the database
        ind_dict={}
        indicator_name="PT.1.Pu.Exp1t2"
        indicator_values=self.column_operation(["T.1.Pu.Exp1t2",0],["T.1.Pu",0],div)
        # We prepare a dictionary for the function write_indic_sql
        ind_dict[indicator_name]=indicator_values
        self.write_indic_sql(ind_dict)
```

We can test the new indicator with the following code

```
test_object=tests_indicators(path_to_database,year,country_name,'test_user')
test_object.proportion_public_teachers_1t2exp_isced1()
```

where `path_to_database` is a string with the full path to the database file, `year` the data year, i.e 2014, for which the indicator is being computed and `country_name` is the country name of interest. In order for this to work, a questionnaire for the corresponding country and year should have been already inserted in the database. After running the command above, it is possible to check the computed indicator directly in the database. To do this, open the database with sqlite and run the following command:

```
SELECT IND_ID ,ADM_CODE, FIG FROM  EDU_INDICATOR_EST AS A
JOIN COUNTRY AS B ON A.CO_CODE = B.CO_CODE
WHERE B.CO_LONG_NAME= country_name ;
```

Notice that `country_name` above has to be changed for the actual name of the country you are using for the test.

Let us say that now you feel confident with your indicator function and that you want it to be included in the indicators computed by the GUI. What you need to do is to copy your method that computes the indicator into the indicators class in the `/RMS/Libraries/rmindicators.py` file. After doing this you need to add a call to this method in the `compute_all_indicators`.

In our example, we copy the following code from the `tests_indcators` class above:

```
def proportion_public_teachers_1t2exp_isced1(self):
          # The following is a dictionary used for inserting the value in the database
          ind_dict={}
          indicator_name="PT.1.Pu.Exp1t2"
          indicator_values=self.column_operation(["T.1.Pu.Exp1t2",0],["T.1.Pu",0],div)
          # We prepare a dictionary for the function write_indic_sql
          ind_dict[indicator_name]=indicator_values
          self.write_indic_sql(ind_dict)
```

and paste it after the line

```
class indicators():
```

in the file `RMS/Libraries/rmindicators.py`. Finally add the line

```
self.proportion_public_teachers_1t2exp_isced1()
```

to the body of the function `compute_all_indicators` between the `self.audit_trail` functions.

Now if you use the GUI to calculate indicators, your new indicator should appear in the drop-down list of indicators.

4 Code Documentation

This section explains how to process questionnaire data for the RMS questionnaire using Python code directly, instead of the Graphical User Interface (GUI). The first step is to import the library `rmquestionnaire` in `RMS\Libraries`, you can use the following code example.

Code example 1 Library import

```
import sys,os
os.chdir(path_to_main_RMS_folder)    # replace path_to_main_RMS_folder
sys.path.append('Libraries')
from rmquestionnaire import *
```

Replace `path_to_main_RMS_folder` for a string with the full path to your main RMS folder.

4.1 Processing a questionnaire

In order to import data from a questionnaire the `questionnaire` class should be used. Four arguments are needed when an object from this class is initiated: the excel file name, the database file path and the log folder path and a user name. The following is an example.

Code example 2 Instating the questoinnaire class

```
excel_file="Regional_Survey_2015.xlsx"
database_file= "Database/Prod.db"
log_folder="/tmp/log/"
username="user"
qobject=questionnaire(excel_file,database_file,log_folder,username)
```

By initiating the `qobject` as shown above, the class reads the file to know if the questionnaire is being imported for the first time or if it is an `Edit` mode questionnaire and what database series to use i.e. OBS,

REP or EST. Also, `questionnaire` checks that the country name used in the file exist the in database, otherwise, an error is raised.

4.1.1 Preprocessing

1. Validation Before extracting the data there is a validation step that takes place, similar to when using the GUI. This is done by the method called **validation** in the `questionnaire` class. It works by calling in order the following methods from the class.

   check_nadm1 Returns `True` if the number of administrative divisions is filled and `False` otherwise.

   check_adm1_label Returns `True` if the label of administrative divisions is filled (e.g. state, province, etc.) and `False` otherwise.

   check_adm1_names Returns `True` if the name of each administrative division if filled and `False` otherwise.

   check_reference_year Returns `True` if the reference year (Cell `M14` in the Administrative divisions sheet) is filled in the questionnaire.

   check_country_name Returns `True` if the country name is filled and `False` otherwise.

   check_number_of_sheets Returns `False` for an original questionnaire where the number of sheets does not coincide with the number of sheets originally provided in the questionnaire. In any other case it returns `True`.

   check_edited_configuration_part Returns `False` for an edited questionnaire without the information table in the top left corner. In any other case it returns `True`.

   check_values Checks that all the values reported in the questionnaire are a positive integer or a reference or A,N,Z,M. If this is the case it returns `True`, otherwise it returns `False`.

   validation returns `True` when all of these checks return `True`. If at least one of them returns `False`, **validation** returns `False` and in this case the questionnaire should not be processed. A validation report with some information of the questionnaire and the results of the checks is written in a file with name syntax `countryname_datetime_validation.txt` in the `Log` folder.

   Using the previous code box, you can run this as

Code example 3 Instating the questoinnaire class

```
qobject.validation()
```

2. Data Report

   After a successful validation step, there might be missing data or inconsistencies in the questionnaire. These are not considered an impediment for processing the questionnaire. They are reported in the data report; a file with name syntax `countryname_datetime_data_report.csv` saved to the `Log` folder.

   The data report is generated by the method **write_data_report** in the `questionnaire` class. It is a csv file divided in three parts.

   The first part is called "Missing data". It lists the sheet name, table name and columns that contain missing data in the questionnaire.

   The second part is called "Data Issues". The following four types of inconsistencies are reported in this section.

(a) Undefined references. This is a cell with the value X with no column number.

(b) In the cases where some columns should have values smaller than others in different columns,the method **check_less** validates these cases. In this method there is a dictionary called `check_less_dictionary` whose keys are table names and the values are a list of pairs with column numbers. For each pair in the list the first column should have smaller values than the first ones. Extra checks of this type can be easily added by just adding the desired columns to this dictionary.

(c) There are some groups of columns when added should give other columns (for example private and public should give the total). When this does not happen this is written in the data report. The check is done with the method **check_column_sums**. In this method the local dictionary variable `check_columns_sums_dictionary` has keys with table names and the values are lists of pairs. The first element of each pair is a list of column numbers whose values should add to the column number given as second element of the pair. It is possible to easily add more checks of this type by just editing this dictionary.

(d) The values of all the regions should add to the country total. The cases where this does not happen are reported. This is done with the help of the method **check_region_totals**.

The third and last part of the data report consists of a list of all the items in the `Checking sheet` of the questionnaire that have the value `No`.

Before calling the **write_data_report** method it is necessary to call the following three methods: **check_region_totals**, **check_less**, **check_column_sums**. These methods populate the attribute `data_issues_dictionary` that is used by **write_data_report**.

The following code performs the validation step and data report for the example we have been developing.

Code example 4 Validation and Data Report

```
if qobject.validation():
    qobject.check_region_totals()
    qobject.check_less()
    qobject.check_column_sums()
    qobject.write_data_report()
```

4.1.2 Data and comments extraction

The `extract_data` method reads the values and enters them in the database. It also writes the region names to the regions database if an original questionnaire is being inserted the first time. The values are also inserted in the audit trail table with the current timestamp, if there is a change from the previously inserted version. For more details about audit trail functionality read Audit trail section.

There are two different types of comments, cell comments and table comments. The cell comments are part of Excel functionality, while table comments are on the top of each table in the questionnaire. Cell comments can be imported to the database with the `extract_comments` method and table comments with the `extract_table_comments` method.

The following lines of code extract the data, cell comments and table comments and add them to the database.

Code example 5 Extracting Data and Comments

```
qobject.extract_data()
qobject.extract_comments()
qobject.extract_table_comments()
```

4.2 Computing indicators

After extracting the data and putting it in the database it is possible to compute indicators. The indicators are only computed form the 'EST' series. At this point we have imported the data to the reported series ('REP'). We need to copy the data to the estimated series ('EST') in order to compute the indicators. This can be achieved using the **moveSerie** function. Before using this function it is necessary to tell the program what database file is being used. This is done with the function **set_database_file** which receives as the only argument the full path to the database file. It was done this way since one might want to interact with the database without importing a questionnaire.

Code example 6 Moving data to the EST series

```
set_database_file('Database/Prod.db')
co_code = qobject.country_code
year = qobject.emco_year
from_serie='REP'
to_serie='EST'
moveSerie(co_code, year, from_serie, to_serie)
```

After the EST series have been populated, we can compute the indicators. This is done with the **rmindicators** class. After having instantiated an object of this class for the desired country and year, the method **compute_all_indicators** will compute and fill the indicators table. Here is example code which instantiates this class for the data used in the example script being developed along this section.

Code example 7 Computing indicators

```
database="Database/Prod.db"
emco_year=2015
country_name="Lao People's Democratic Republic"
ind_object=indicators("Database/Prod.db",2015,"Lao People's Democratic Republic",username)
ind_object.compute_all_indicators()
```

4.3 Exporting data

4.3.1 Exporting questionnaire data

In order to export the questionnaire data from the database to an excel file, the `xlsxwriter` modules needs to be used in combination with the function `export_var`. As shown in the following example, first the excel workbook needs to be created and then `export_var` needs to be called for each desired sheet.

After running this code an excel file with name syntax `countryname_2015.xlsx` is created containing the data of all the sheets that were passed to **export_var** before `wb.close()`. Notice that `serie` can take one of the values 'REP', 'OBS' or 'EST' which correspond to reported, observed and estimated database respectively.

Code example 8 Exporting data to an excel file

```
import xlsxwriter

co_name = qobject.country_name
filename = "{0}_{1}.xlsx".format(co_name, 2015)

wb = xlsxwriter.Workbook(filename)

export_var('Administrative divisions', wb, co_code, year, var_type = "sheet")
export_var('Pupils', wb, co_code, year, var_type = "sheet")
export_var('Teachers ISCED 1', wb, co_code, year, var_type = "sheet",serie= 'REP')
export_var('Teachers ISCED 2', wb, co_code, year, var_type = "sheet",serie= 'REP')
export_var('Teachers ISCED 3', wb, co_code, year, var_type = "sheet",serie= 'REP')
export_var('Teachers ISCED 23', wb, co_code, year, var_type = "sheet",serie= 'REP')
wb.close()
```

4.3.2 Exporting indicators

It is also possible to export an excel file with the values of all the indicators or for one of them. This can be achieved with the function **export_indc**. In order for this function to work it is also necessary to first call the function `set_database_file`.

One can export one indicator or all of then to an excel file. If `All` is passed as an argument to **export_indc** then all the indicators are exported. The other option is to pass the name indicator ID of the desired indicator (e.g. 'NTP.1').

Code example 9 Exporting indicators to an excel file

```
indicators_filename="{0}_{1}_indicators.xlsx".format(co_name, 2015)
indicators_wb = xlsxwriter.Workbook(indicators_filename)
export_indc("All", indicators_wb, co_code, year)
indicators_wb.close()
```

4.4 Software folder tree

The following is the RMS software directory tree, where all directory levels are printed, following that the complete tree including individual files.

```
RMS/
|-- Database
|   `-- Inserted data
|-- Documentation
|   |-- css
|   |-- img
|   `-- Python help
|-- Export
|-- Import
|-- Libraries
`-- Log

10 directories
```

```
RMS/
|-- Database
|   |-- Inserted data
|   |   |-- ADM_table.csv
|   |   |-- All AC CODES.csv
|   |   |-- Country.csv
|   |   |-- EDU_INDICATOR_AID.csv
|   |   |-- EDU_INDICATOR_AID_full.xlsx
|   |   |-- EDU_METER_AID(data).csv
|   |   |-- Magnitude(data).csv
|   |   |-- NEW AC CODES inserted in EDU_METER_AID.csv
|   |   |-- Qualifier.csv
|   |   |-- RM_Mapping.csv
|   |   `-- RM_Mapping_NonNumeric.csv
|   |-- create_database.bat
|   |-- create_tables.sql
|   |-- insert_data.sql
|   |-- insert_indic_labels.sql
|   |-- library.sql
|   |-- main.sql
|   |-- migration_to_DB_with_indic.sql
|   |-- Prod.db
|   `-- README.md
|-- Documentation
|   |-- css
|   |-- img
|   |-- Python help
|   |   |-- rmExcelWriter.html
|   |   |-- rmfunctions.html
|   |   |-- RM_GUI.html
|   |   |-- rmindicators.html
|   |   `-- rmsqlfunctions.html
|   |-- README.md
|   |-- user-manual.html
|   |-- user-manual.org
|   |-- user-manual.pdf
|   `-- user-manual.tex
|-- Export
|   `-- README.md
|-- Import
|   `-- README.md
|-- Libraries
|   |-- algebra-div.csv
|   |-- algebra-prod.csv
|   |-- algebra-sum.csv
|   |-- Pip install.md
|   |-- README.md
|   |-- rmExcelWriter.py
|   |-- rmfunctions.py
|   |-- rmindicators.py
|   |-- rmquestionnaire.py
|   |-- rmsqlfunctions.py
|   `-- variables_for_preprocessing.json
|-- Log
|   `-- README.md
|-- README.md
`-- RM_GUI.py

10 directories, 46 files
```

4.5 Python help files

Python had its own help documentation that could be created using `pydoc` for any script. In the Software folder tree section, the tree lists 6 `.py` files, 5 in folder `/Libraries` and the `RM_GUI.py` in the main directory. The following are the links to the Python help files of each.

- Libraries/rmExcelWriter.py
- Libraries/rmfunctions.py
- Libraries/rmindicators.py
- Libraries/rmsqlfunctions.py
- `Libraries/rmquestionnaire.py` does not have a help file since it only loads all the other scripts.
- RM_GUI.py