Automation in calculation and presentation of educational indicators

https://indikatoren.iqs.gv.at/

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uRos Conference (online), December 3rd, 2020

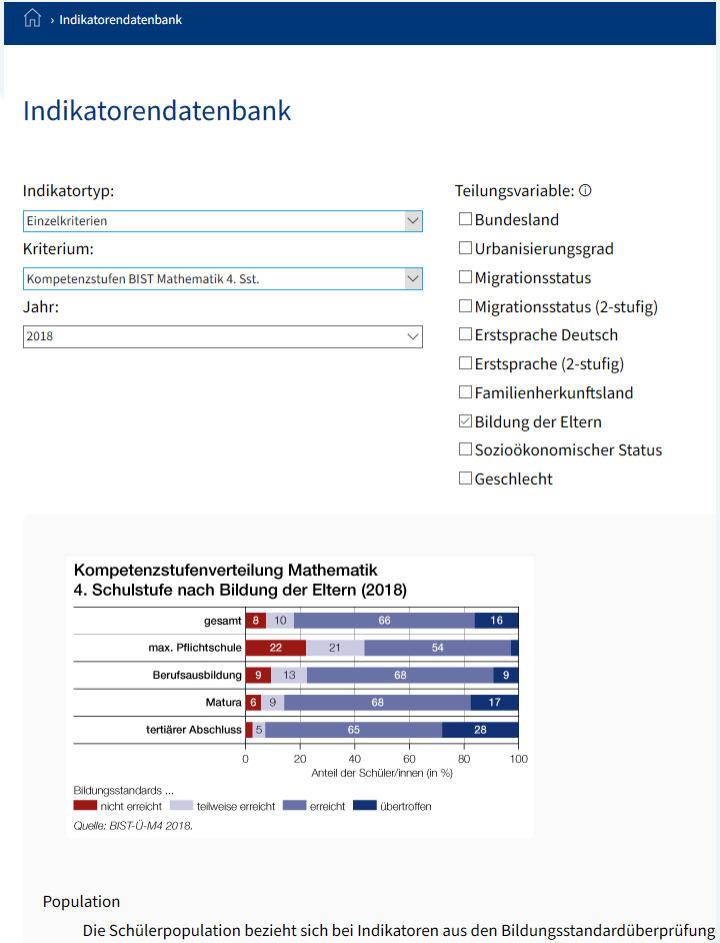
The database of educational indicators of the IQS

- In Austria, IQS is responsible for national (*Bildungsstandards*) and international assessment (PIRLS, TIMSS, PISA) of students learning outcomes → result: official statistics
- Predecessor organizations (mostly BIFIE) have done this since 2000, providing conventional reports, follow-up analyses, compact overviews etc. (see our website)
- Educational indicators for monitoring of the school system may also be found in the National Education Reports (2009, 2012, 2015, 2018) which provide all reported statistical coefficents in supplement data sheets online.
- Limitations of linear (text) formats of presentations led to the development of a database of such indicators in 2019.

The database of educational indicators of the IQS

- Goals:
  - Provide a global and public entry point to our statistics
  - Facilitate exploring contents but also comparing and combining indicators from our different studies and data sources → facilitate secondary analyses
  - Make citation possible by the means of permanent designations for indicators
- Restrictions in development:
  - Limited manpower and resources (~3 full-time equivalents)
  - Quick results (9 months)

- Indicators are organized in a tree-like structure:
  1. General type of indicator
  2. Criterion (state or trend of the school system)
  3. Year (or time period)
- Optionally, information may be split by up to two variables (regional or demographical subgroups) depending on criterion and data source
- Semi-dynamical behavior: image (graph), meta-information and links for downloads are fetched from the server → content exists beforehand, no calculations are done by the web application



- Along with the graph, all coefficients (and supplement informations, eg. standard errors or absolute frequencies) are available as Excel spreadsheets.
- Highest possible numerical precision for re-usage in publications or further calculations.
- Eg. *E_bist-m4_2018_bil.xlsx*

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	**Kompetenzstufenverteilung Mathematik 4. Schulstufe nach Bildung der Eltern (2018)**													
2	Quelle: BIST-Ü-M4 2018.													
3														
4	**Merkmalskombination**	**Vorkommen der Merkmalskombination (in %)**	**Anteil Schüler/innen (in %) mit Bildungsstandards ...**				**Standardfehler (in %)**				**Anzahl Schüler/innen**			
5	**Bildung der Eltern**	**gesamt**	**nicht erreicht**	**teilweise erreicht**	**erreicht**	**übertroffen**	**nicht erreicht**	**teilweise erreicht**	**erreicht**	**übertroffen**	**nicht erreicht**	**teilweise erreicht**	**erreicht**	**übertroffen**
6	gesamt	100,00%	7,51%	10,27%	66,17%	16,04%	0,06%	0,10%	0,11%	0,07%	5745	7854	50583	12265
7	max. Pflichtschule	7,58%	22,16%	21,41%	53,68%	2,75%	0,39%	0,58%	0,38%	0,13%	1283	1240	3108	159
8	Berufsausbildung	40,87%	9,34%	13,21%	68,30%	9,15%	0,10%	0,20%	0,21%	0,13%	2917	4125	21338	2859
9	Matura	22,19%	5,72%	8,50%	68,29%	17,49%	0,07%	0,10%	0,21%	0,14%	970	1441	11580	2965
10	tertiärer Abschluss	29,39%	2,56%	4,67%	64,81%	27,96%	0,06%	0,13%	0,16%	0,14%	574	1048	14558	6281
11														
12	**Anmerkungen:**													
13	Population	Die Schülerpopulation bezieht sich bei Indikatoren aus den Bildungsstandardüberprüfungen auf die testrelevanten Schüler/innen auf der jeweiligen Schulstufe. Ausgeschlossen sind dadurch u.A. außerordentliche Schüler/innen und solche, die nach de												
14	Kompetenzstufen	Die Cut-Scores für Mathematik auf der 4. Schulstufe liegen bei (ab) 410 Punkten (teilweise erreicht), 458 Punkten (erreicht) und 652 Punkten (übertroffen).												
15	Bildung der Eltern	Entspricht der höchsten elterlichen Ausbildung. Die Kategorie "Berufsausbildung" umfasst abgeschlossene Berufsschulen und berufsbildende mittlere Schulen (BMS). Die Kategorie "tertiärer Abschluss" beinhaltet Abschlüsse an einer Universität, Fac												

Social scientists vs. Programmers

The social scientists …

- want to think about content
- anticipate a lot of different indicators from different data sources
- are concerned with validity, quality assurance, meaning and impact
- fear disclosure and mind privacy
- use R, but no other programming language

The programmer(s) …

- need to have clear goals and stable specifications
- can‘t anticipate exceptions
- rely on the social scientists for privacy requirements to be fulfilled
- don‘t use R, but all kinds of other programming languages

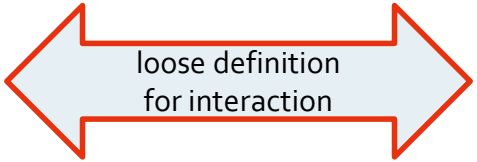
So we decided …

The social scientists …

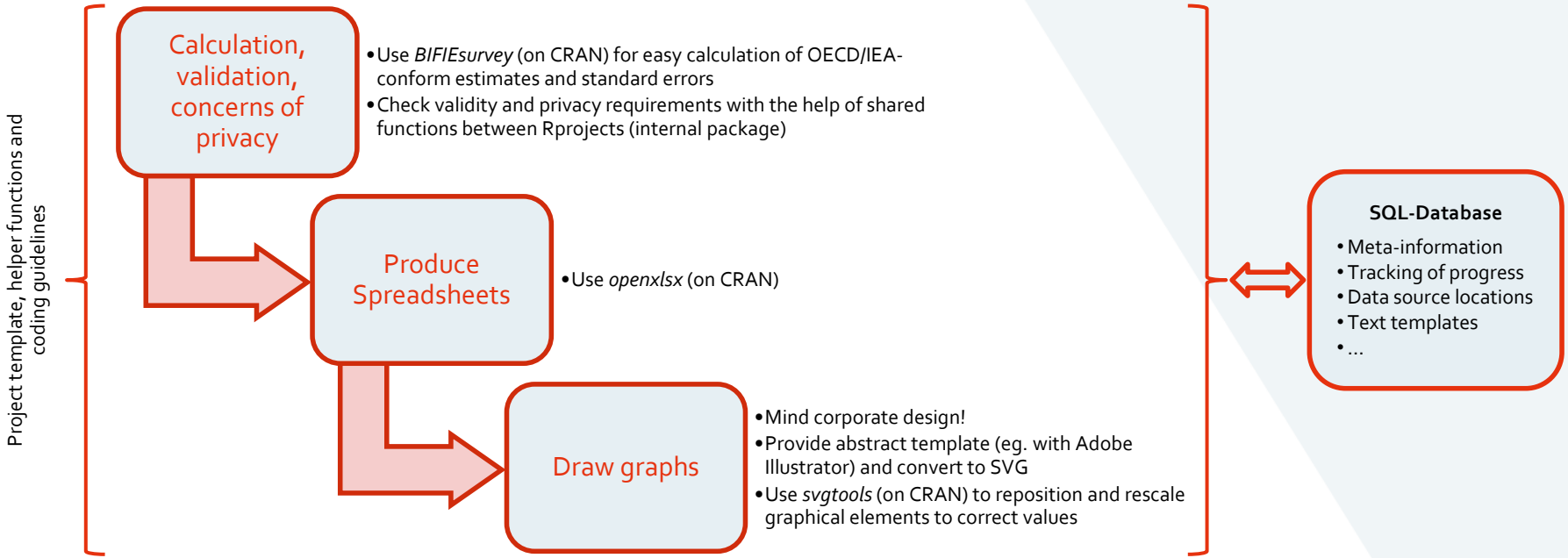
- produce the content: jpg- and xlsx-files as well as meta-information
- validate, do the quality assurance, check for possible violations of privacy
- … using R

The programmer(s) …

- develop the web application
- take responsibility for usability and maintenance
- publish new indicators by request of the social scientists
- … using their programming tools



Rprojects for groups of similar indicators



BIFIEsurvey (BIFIE, Robitzsch & Oberwimmer, 2019)

- Calculates estimates and standard errors for reporting of large-scale assessments. Conforms to OECD (PISA, TALIS, PIAAC) and IEA (PIRLS, TIMSS) reporting guidelines as well as the definitions for the assessment of *Bildungsstandards* in Austria.
- Faster and easier to use than *survey*, *mitools* or similar packages (code for estimation runs in native C).
- One line of code to encapsulate data and data structure parameters (sampling weights, replicate weights, jackknife zones, plausible values, multiply imputed values) into object of class *BIFIEdata*.
- Eg. baseline study for assessment of *Bildungsstandards* (10 imputed datasets in a list, 132 replicate weights from jackknife procedure):

```
dat.bd <- BIFIE.data(dat, wgt="wgtstud", wgtrep=dat[[1]][,paste0("w_fstr",1:132)], cdata=TRUE)
```

BIFIEsurvey (BIFIE, Robitzsch & Oberwimmer, 2019)

- Afterwards, easy to use functions for typical reporting needs (frequencies, univariate statistics, correlations, linear and logistic regression, quantiles):

```
myResult <- BIFIE.freq(BIFIEobj = dat.bd, vars = "y", group = c("x1","x2"))
```

- (… but also more complex models)
- Standardized output format of results (estimates and standard errors in long table format) allows for helper functions concerning privacy:
  - check for k-anonymity (k=5)
  - check for zero variance (also in categorical variables)

openxlsx (Schauberger & Walter, 2020)

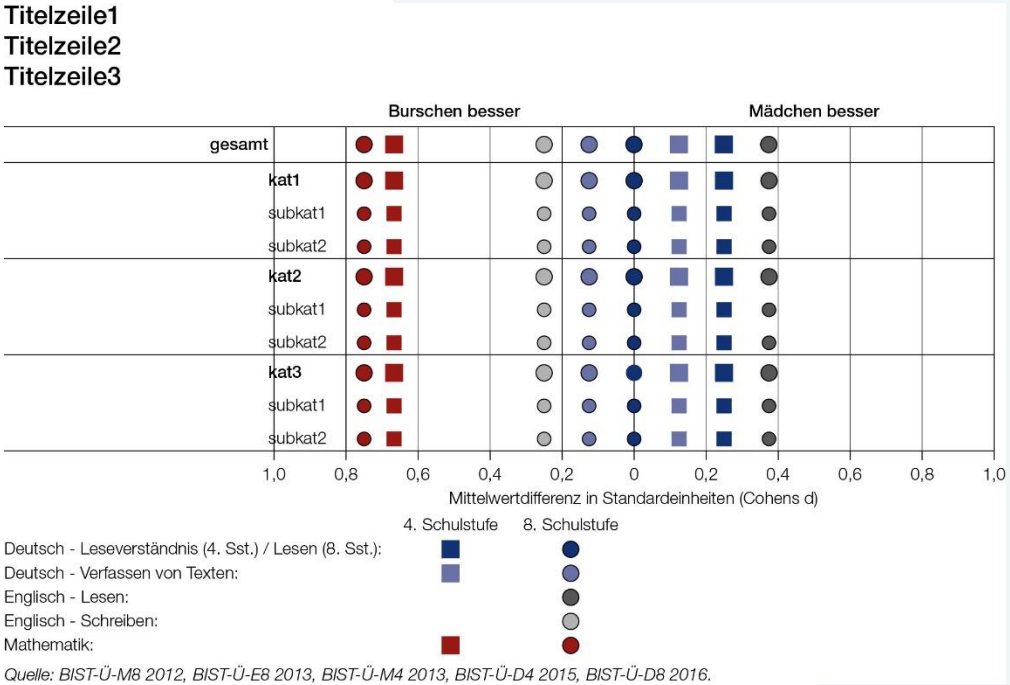
- In my opinion, the best package for creating xlsx right now.

svgtools (Oberwimmer & Wimmer, 2020): templates

Part of SVG structure:

```
<rect id="Rahmen" x="155.905" y="58.319“
  width="340.157" height="153.073"/>

<g id="k1m8">
  <circle cx="198.425" cy="83.821" r="3.838"/>
  <circle cx="198.425" cy="99.412" r="3.199"/>
  <circle cx="198.425" cy="115.002" r="3.199"/>
</g>
```



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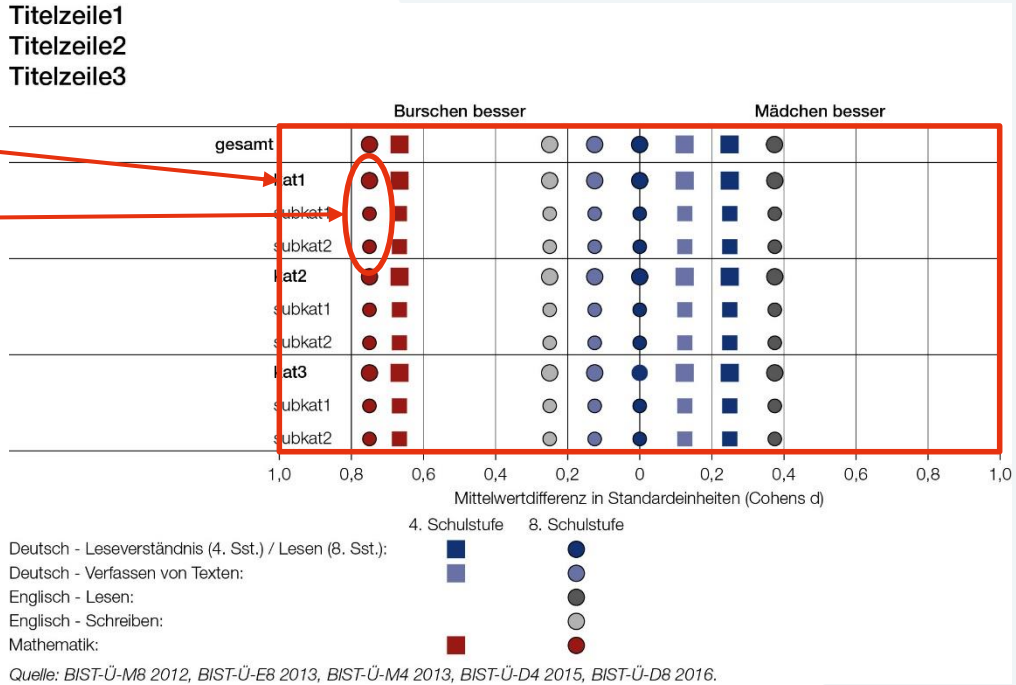
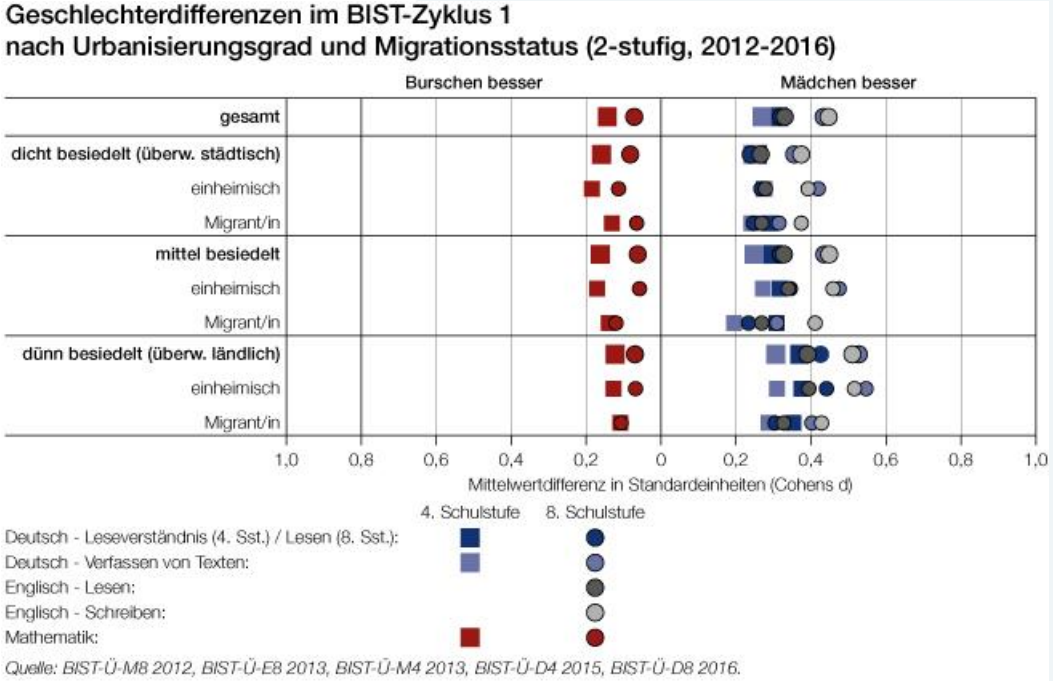


svgtools (Oberwimmer & Wimmer, 2020): usage

```
svg <- linesSymbols(
        svg = svg,
        frame = "Rahmen",
        group = "k1m8",
        scale_real = c(-1,1),
        values = calcuted.values,
        alignment = "horizontal",
        has_lines = FALSE,
        symbol_type = "circle")

svg <- changeText(
        svg = svg,
        element_name = "kat2",
        text = "mittel besiedelt",
        alignment = "end")
```



Overall perspective and conclusion

- Given limited resources and development time: fine combination of tools and procedures to generate a predefined set of educational indicators
- Re-production of all current ~1000 indicators takes ~2 hours on a standard PC (not counting manual validation steps)
- Generating a new set of indicators takes about a week for one scientist
- Limitations:
  - to predefine what we want ☺
  - reacting to „popular“ oder administrative demands for knowledge difficult
  - social scientists with better skills in R needed (not fearing loops and database access)