Teaching for Citizen Empowerment and Engagement

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High-school and undergraduate curricula in statistics have been criticised *inter alia* because of: a focus on tractable mathematical models; use of toy data sets; a belief in 'simple to complex' pedagogy; a focus on generalising from small samples to populations; and an over-emphasis on significance testing (e.g. Cobb, 2015; Ridgway, 2015). Questions asked of students rarely relate directly to anyone's lived experiences. This is in sharp contrast to the early days of statistics, when the discipline arose from the need to solve practical problems. In these early days, people with widely differing expertise came together to address problems in agriculture, economics, health, social equality, meteorology and human sciences, often inventing new mathematical models in the process (see Pullinger, 2013). A radical rewrite of the curriculum is overdue: we should teach about socially important topics, use real data, and modern tools and associated ideas.

There is a long tradition of arguing that better information to citizens about social issues will lead to social change, illustrated by Condorcet's (1792) *savoir liberateur*, and the Neuraths' work on Isotype (e.g. Neurath, 2010); Radical Statistics is an inheritor of this tradition. So what might a curriculum for empowerment and engagement actually look like? There are two key elements: offering ways to access data; and developing skills in data wrangling and communication.

Reasoning about social issues can be problematic. There is a great deal of information to hand, often gathered carefully by governments and NGOs such as OECD, Eurostat, the World Bank and the UN. Users need to understand something of the processes of data collection and analysis. A fundamental principle is that data are collected by people with some purpose in mind; the choice of issues to address, the creation of measures, data gathering, data cleaning and data presentation all reflect political, philosophical, and practical choices. The use and measurement of GDP, the UN's Sustainable Development Goals, and 'good university' guides provide examples. Measures in the social world have characteristics that make them unsuitable for simple analysis and simple conclusions. Phenomena are multivariate; variables are often correlated; they often interact; there are non-linear relationships; there may be causal relationships. Data are often aggregated, and grouped in diverse ways. Indicator systems are common, and are strongly theory based e.g. should 'poverty' be an absolute or a relative measure? Phenomena change over time, and there are often seasonal variations. Most social phenomena can be illuminated by data from different data sets. Assertions about social phenomena are often embedded in rich text, replete with rhetorical flourishes; novel data visualisations continue to be created, and users need to learn how to read them.

The ProCivicStat project was a three-year project funded by the ERAMUS+ programme and involved a collaboration between six partners in five countries. We created:

- A conceptual framework, mapping out ideas about the components of statistical literacy
- Several hundred hours of teaching materials that can be downloaded - indexed in a variety of ways such as social topic, or key statistical ideas
- A review of dynamic visualisation tools and relevant statistical packages
- Links to data sets
- Sample syllabi
- Workshop materials for teacher professional development
- Tools for analysing tasks, assessment systems and curricula

These can all be found at https://iase-web.org/islp/pcs/.

The conceptual framework and the tool for accessing teaching materials are described briefly, below.

Conceptual Framework

Figure 1 shows our conceptual framework for statistical literacy. There are three broad groups of facets, related to: engagement and action; knowledge; and enabling processes.
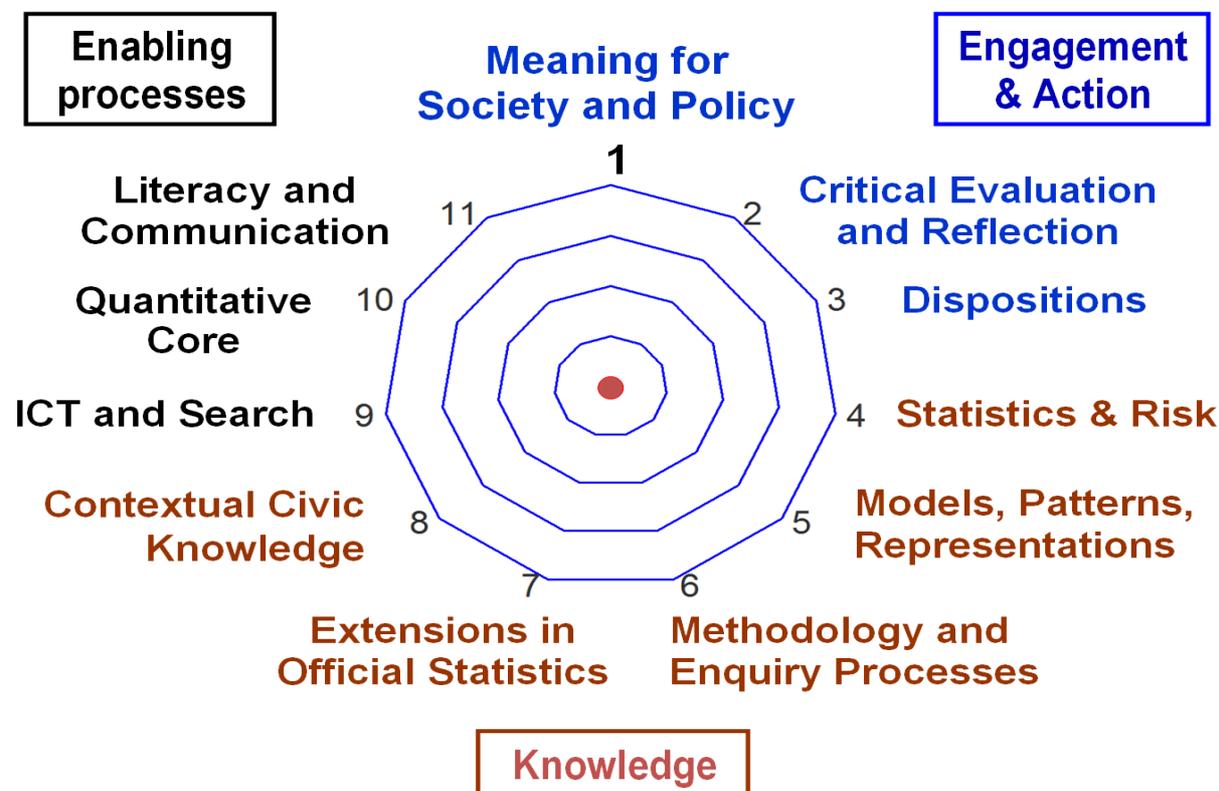

Figure 1: Conceptual Framework

Of these, the most important is *Engagement and Action.* Willingness to engage with social problems (Dispositions), the ability to evaluate evidence (Critical Evaluation and Reflection) and the ability to see the implications of evidence for social policy (Meaning for Society and Policy) are key components. Under *Knowledge* we advocate a broadening of current curricula. The whole process of thinking how a particular issue might be represented and modelled (Models, Patterns and Representations) needs to be problematised; students need to know that (say) using default values in SPSS is actually adopting a specific theory of the phenomenon being modelled. The whole process of exploring social phenomena (Methodology and Enquiry Processes) needs to be explored; critical evaluation depends on an understanding of the strengths and limits of different methodologies. Official statistics is under-represented in many curricula; knowledge about key issues such as inventing measures, sampling, data cleaning and data representation are essential to understanding the uses and limitations of data from National Statistics Offices, OECD and the UN (Extensions in Official Statistics). These authoritative sources provide a good starting point for discussing the politics of data – who decides to collect what information for what purposes? These sources can also provide vivid illustrations of practical challenges to collecting robust evidence. Carr-Hill (2013) argues that household surveys in developing countries can systematically under-represent key subgroups, such as slum-dwellers and nomads. He provides evidence of large, systematic, biases in estimating the numbers of the poorest people in society – data critical for informed policy making. There are also conceptually exciting ideas around the problems of combining carefully curated data with feral 'big data'. Judgements about risk, costs and benefits, expected values, probabilities and

subjective probabilities are central to policy decisions (Statistics and Risk), but often receive scant attention in conventional curricula. The last facet in this group is Contextual and Civic Knowledge. In discussions about migration, for example, it is important to know that it is likely to be easier for Germany (population 82 million) to absorb 1 million migrants than for Hungary (population 10 million) to do so, other things being equal. It is essential to know that other things are NOT equal. *Enabling Processes* comprise Literacy and Communication, Quantitative Core, and ICT and Search. ICT and Search includes the ability to read and critique novel data visualisations, and to be aware of major sources of information and disinformation (such as deep fake videos).

A fuller description of the conceptual framework can be found here https://iase-web.org/islp/pcs/documents/Conceptual_framework_long.pdf

Teaching Materials

We have created 42 teaching modules that correspond to several hundred hours of teaching time, all presented using a common framework. For each module, there is a teacher version and a student version. A sample of an introductory panel is shown in Figure 2; these have been designed to facilitate browsing by potential users.

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A few so rich, others so poor - income inequalities in Europe

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What?	Teaching Material for learning statistics about society: *Investigating income inequalities in Europe*
Why?	Learning statistics with real data and motivating topics of high relevance for informed citizenship and civic engagement
Statistics topics	Students will be able to investigate multivariate data, compare distributions, analyze subgroups, understand percentiles, investigate trends and time series
Level	Intermediate
Prerequisites	Boxplots, location parameter, scatterplots
Digital tools	CODAP, iNZight or iNZight Lite
Resources needed	CODAP or iNZight Lite (browser-based) needs PCs or notebooks with access to the internet, or iNZight must be installed on PCs
Lesson time	3 - 5 hours
Further remark	Suitable for group work or home work assignment; some intro to the software needs to be provided

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Figure 2: Panel from a PCS Teacher's Manual

Fuller details are provided in subsequent sections, such as information about ways to access and drive the (free) software; vices and virtues of the digital tools recommended (here CODAP vs iNZight); information about the context, in the form of links to websites or documents; advice on

how to use the worksheets; and some possible solutions (given the nature of the analyses we invite, there is no single correct answer).

The Students' Worksheet begins with brief sections entitled: *what is inequality?; why does it matter?; how is it measured?* Students are provided with background information, and are then introduced to the data source, and the list of variables (which include income share by deciles of the population D1 – D10), before progressing to specific tasks. The first questions are about values (*If you had the choice: would you rather live in…*). These progress to specific activities and questions, linked via a guiding question: *why in some countries are there large discrepancies between the rich and poor while in other countries the income distribution is more equal? What have countries in common that have a large discrepancy between rich and poor?. Explore and analyse the dataset in search of answers. Try to draw conclusions by means of suitable graphical representations and statistical calculations. How certain are you about your discoveries? The following considerations may guide your investigation.*

- *Study the distribution of D10 and D1. What characteristics do countries with a high D10 value have in common? Describe the shape of the distribution, location, spread, skewness etc. What do countries with a high D1 value have in common?*
- *Create a scatterplot of D10 versus D1 and try to fit a line. What is the meaning of the slope? Why is it negative?*
- *Define a new variable D10/D1 as quotient of D10 and D1 and study its meaning and its distribution.*
- *Is there a relation between mean income and the new variable D10/D1? Explain why or why not?*
- *Now investigate the trend of the variable D10/D1 over the years for Portugal, Switzerland and Turkey. Which commonalities do you observe? Which differences?*

Students are asked to pose two further questions themselves, and to draw conclusions. They are asked how confident they are about their conclusions, and are then asked to produce a counter-argument to their own conclusions.

CivicStatMap

CivicStatmap offers a way to access the teaching resources we have created. A snapshot of the interface is shown in Figure 3. Resources have been created for high school, college and university students. Topics include refugees, alcohol consumption, migration, poverty, racism in football, malnutrition and natural disasters. A wide variety of data sets is used; sources include the World Health Organisation, OECD, the United Nations Children's Fund, Program for international Student Assessment (PISA) and the Center for Disease Control. Commonly used visualisation tools are iNZight, JMP, Tableau, R and CODAP.

Users can search for resources on the basis of one of, some of, or all of: social theme (e.g. climate; happiness); resource or data set (both microdata and microdata); visualisation tool (e.g. RAW, Gapminder); statistical topic (e.g. Gini, Chi-squared); graph type (e.g boxplots, scatterplots); education level (e.g. high school; university); and language (e.g. Portuguese, Hungarian).

Figure 3: CivicStatmap

Associated Resources

Other resources are available on the ISLP/PCS website https://iase-web.org/islp/pcs/. These include sample syllabi, that have been used in partner universities, based on the PCS materials. There are workshops to facilitate professional development, that have been used at conferences for statistics educators in Berlin, Rabat and Kyoto. A review of dynamic visualisation tools and relevant statistical packages is also available, and is described in more detail in Ridgway *et al* (2017).

Conclusions

Radical Statistics focusses on engagement with important social issues. Many statistics curricula – especially at the introductory level – focus on the mastery of simple statistical techniques, devoid of any substantive content. One consequence of this can be that students are ill-equipped to address issues where there is any level of complexity – such as non-normal distributions, multiple relevant variables that interact, or change over time. Another consequence may be that student perceive statistics as being irrelevant to anything in which they are interested (and difficult, and dull). The ProCivicStat project set out to create and validate resources for teaching that address these problems, and to make these materials easy to access. We hope that this is a useful contribution to support the visions of Condorcet, the Neuraths and many RadStats members.

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