Statistical Literacy, Globalisation, and the Internet

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Introduction

Condorcet (1792) advocated the idea of *savoir liberateur* – knowledge that would allow people to escape their current circumstances via better knowledge. A number of international agencies – notably UNESCO, The United Nations (UN) and The Organisation for Economic Co-operation and Development (OECD) – are committed to programmes which set out to engage citizens across the world in: a radical reconceptualisation of the meaning of ‚social progress‛; in ways to measure social progress (e.g. The UN Millenium Development Goals (United Nations, 2000)); and in ways to hold governments accountable for promoting social progress through measures that do not have negative consequences for the environment, for long term sustainability, or for citizens of other countries. OECD‛s flagship project in this domain is their Global Project. The goals are set out in the Istanbul Declaration (OECD, 2007) – the scale of the movement can be judged by the impressive range of signatories. Full Partners in the Global Project include organizations such as the UN and The World Bank. Transnational projects are unlikely to succeed without pressure from citizens on governments worldwide.

Many governments have embraced the concept of evidence informed policy, and many have expressed a desire to invigorate democracy by engaging citizens in debates around key issues of social policy, such as health.

A very large number of databases around the world contain data relevant to social policy and to the well-being of individuals. During the past decade there has been a movement towards increasing access to data, via the development of dynamic displays, and towards evidence informed policy. This can be seen as moving from a focus on ‚statistics‛ (the analysis of data about the state) to Giovannini‛s (2008) conception of ‚societistics‛ – the development of information systems to further the progress of societies. A key challenge is to make data comprehensible by a large number of people – to increase the overall level of statistical literacy (SL) in the adult population. The challenges faced by organizations which create official statistics are clear. Most obvious is the poor state of SL in the adult population (e.g. Batanero *et. al* (1994)). There are other pernicious problems, such as the widespread mistrust of national governments and of national statistical offices (Giovannini, 2008), and the practical and technical issues associated with providing data in ways that make public access straightforward. These latter problems are important, but are beyond the scope of this paper.

The International Statistical Literacy Project (e.g. Sanchez, 2008) is doing excellent work promoting statistical literacy, but it is likely to be used by people who have already resolved to improve their SL. The most important and most difficult group to inculcate with SL is adults who are making political decisions. Here ‚political decisions‟ include decisions about the provision and design of programmes in health, education, and social welfare. Close behind are the people who influence these decision makers – this group includes journalists and voters. Very few of these people will devote time to developing their SL. Here, we argue that the only plausible mechanism for improving SL is to use the data sources themselves to educate users; we explore alternative approaches, challenges, and opportunities, with examples.

OECD have run seminars for policy makers about the use of official statistics in shaping policy. We designed an activity for these seminars in which participants are asked to critique a press release from the Irish Central Statistics Office (2008a) (ICSO), and then to use data from the ICSO to create a better version.

PRESS RELEASE by the Irish Central Statistics Office (2008)
Life expectancy at birth was provisionally estimated at 81.5 years for Irish women and 76.7
years for Irish men in the period 2004-2006.
In comparison with 2001-2003, men's life expectancy increased by 1.6 years and women's by
1.2 years, reducing the gap between men and women to 4.8 years in 2004-2006, the lowest it
has been since the 1970-1972 period (Table 6.3)
.

Figures 1 and 2 show data from the Irish Central Statistics Office (2008b), presented in an interactive display. The data has some obvious and important features. One is an interesting trend in the differences between male and female life expectancy over time. Another is the dramatic increase in life expectancy over a short period of time. This has important economic and social implications. The press release misses an opportunity to engage citizens in a discussion of some really interesting data.
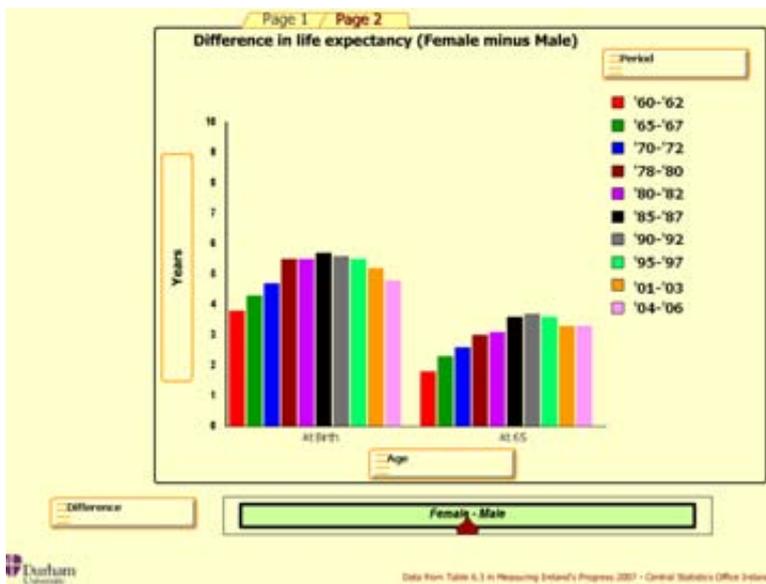

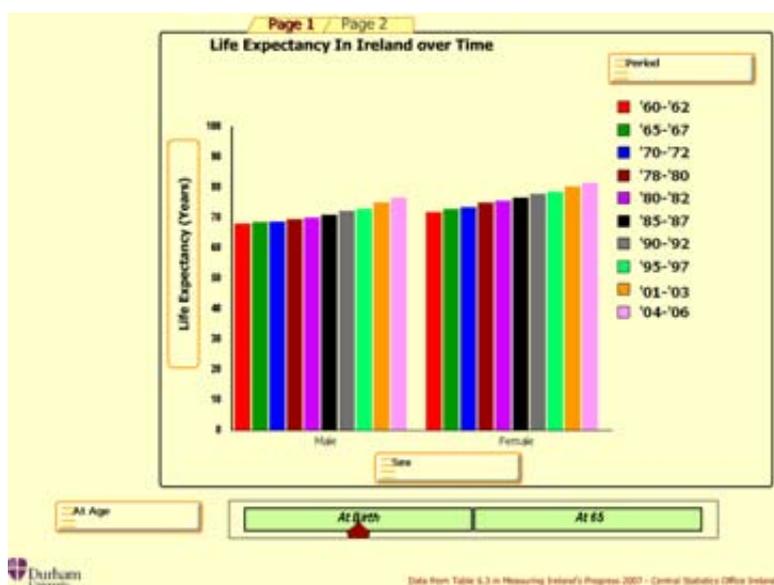**Figure 1**: gender difference in life expectancy in Ireland

Figure 2: life expectancy in Ireland over time

A key challenge is to increase public engagement with statistics, in the face of fierce competition from other activities that are more obviously pleasurable. An important way forward is to engage closely with mass media in as many forms as possible. If evidence is to reach a large public audience, data displays need to be created in ways that makes it easy for TV and internet media to incorporate them into their existing websites, and into a form suitable for direct TV broadcast. Getting important messages in the public eye, by paying attention to the channels of communication that actually work on a large scale, has been shown to be possible (Statistics Finland, Statistics Canada, and the UK Office of National Statistics provide useful models; a forthcoming special edition of the Statistical Journal of the International Association of Official Statistics will provide further examples). This requires a shift from activities geared to dissemination to activities geared at user engagement. This shift puts pressure on providers to understand a good deal about both the competencies of users, and to develop effective communication methods.

Media displays of data could be improved. In some cases (such as print material) the media are inherently limited in what they can show. In other cases, such as video, television or the internet, there is a need for more, and more creative displays of data. In the case of print media, many newspapers have websites associated with them, and these offer the potential to display data interactively. One way forward is to present data in interactive displays on line. An extension of this idea is to create entire interactive documents, and to publish them on line. Jern (2010) shows how this can be done, using OECD data and eXplorer. A sample page is shown in figure 3, where the choropleth map shows the fertility rates in different countries, with four countries (South Africa, Nigeria, Italy and China) highlighted and the time series graph in the bottom panel shows the fertility rates for those four countries between 1960 and 2008, and the scatter plot shows the fertility rate against the proportion of the population aged 0 – 14, with the country population determining the circle size of that country in the scatter graph. The panel on the right here is simply explaining the nature of the displays and the controls, and the interactive options available to the user, including changing the datasets on display, but can be used to tell the story of the data in a teaching context, or to provide guided exploration of the data context.
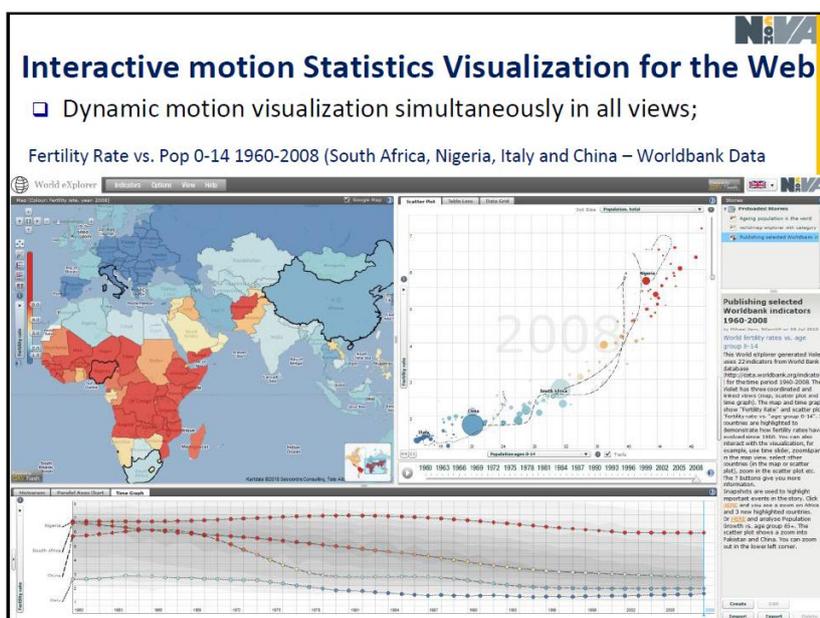
Figure 3: sample interactive document published online

The extraordinary success of Hans Rosling (HR) in promoting interest in statistics is worth analysing as a model for future developments. One can identify a number of important components of Rosling‟s success. These begin with the *Gapminder* software – a wonderfully useful piece of software developed by HR and his family, and now maintained by the Google corporation. HR‟s use of the software is another component – his delivery is arresting: dynamic, eccentric, and provocative. These are key components that attract attention. However, perhaps the most important feature is that the data displayed contain some real surprises: see for example Rosling (2007) - plummeting birth rates and soaring affluence in countries such as China and India that provoke immediate interest. These data provoke questions about future changes in the dominant players in the world economy, predictions that pressures on natural resources and food will increase dramatically and also very rapidly, and that pollution is likely to increase along with rapid industrialisation. A similar feature characterises the television programme he made for the BBC (Rosling, 2010) – the presentation is charismatic, and holds audience attention, but the content is exciting and raises key questions about policy in social affairs. Some important aspects of this model are unlikely to be generally applicable – in particular, finding a presenter with similar charisma (it is rather too much to hope that Statistical Office videos will go viral).

Statistical literacy

Statistical literacy (SL) has many advocates, but there is no clear consensus about what SL is. Wallman (1993) in her Presidential Address to the American Statistical Association offered ",Statistical Literacy" is the ability to understand and critically evaluate statistical results that permeate our daily lives – coupled with the ability to appreciate the contribution that statistical thinking can make in public and private, professional and personal decisions".

Iddo Gal‟s (2002) characterization is " [SL refers to] … the need for people (including learners in both formal, non-formal, and workplace contexts) to develop the ability to comprehend, interpret, and critically evaluate messages with statistical elements or arguments conveyed by the media and other sources".

Both of these views see SL as the ability to comprehend messages that involve some reasoning with data. It is somewhat paradoxical that research exploring and assessing SL has often focused on the problems of understanding seemingly simple statistical ideas, and in dealing with straightforward tasks such as interpreting tables and graphs (e.g. Schield, 2008). The focus on SL is often close to mastery of the technical aspects of school mathematics, such as proportional reasoning, probability, and graph interpretation.

The problems faced by people trying to understand social phenomena is that most social phenomena are multivariate, and involve non-linear relationships between variables. There is usually a number of potentially confounding variables, and each variable may have an effect on the phenomenon of interest over only a particular range of values. It is reasonable to suppose that such complexity will prove to be an insurmountable barrier for any potential user who has no formal training in statistics. Here is an example where educated people (presumably) receiving advice, make statements on important issues that are only partly correct. The context is the attainment of children on a set of the high-stakes examinations („GCSEs‟) taken at the end of compulsory education in England and Wales, which the government‟s target achievement level for a pupil is 5 GCSEs at grade A* - C, including English and Mathematics.

>   Statements in the foreword to the 2010 Education White Paper by the Prime Minister and Deputy Prime Minister (Department of Education, 2010)

- *Children on free school meals do significantly worse than their peers at every stage of their education.*
- *They are just half as likely to get good GCSEs as the average.*
- *This vast gap between rich and poor is not pre-ordained. In Finland and Canada the gap is much smaller. Even in this country there are some groups – Chinese girls on free school meals for example – who significantly outperform the national average.*

If one is making policy decisions about educational provision (or is constructing theories about educational attainment), it is essential to have a detailed understanding of the phenomena. One can ask if differences between boys‟ and girls‟ attainment:

- are the same across socio-economic groups? (eligibility for free school meals is a crude indicator of low socio-economic status)
- across all ethnic groups?

Figures 4 - 6 show the performance of pupils for a number of ethnic groups, separating out the associations with free school meals (FSM), ethnicity and gender. Variable labels (FSM?, ethnic group, sex) can be dragged to different locations – this allows the relationships to be explored actively (see the interactive display at www.dur.ac.uk/smart.centre/nuffield, data from Department of Education, 2009).

Figure 4 shows there are substantial differences in performance between White, Mixed, Asian and Black groups for those eligible for FSM, with White pupils performing particularly badly. In every group, girls outperform boys, but by different amounts. Pupils not eligible for FSM show a very different pattern of achievement across the various ethnic groups: again girls outperform boys in every ethnic group, but the only noticeable differences are that the Chinese do better and Black do worse than the other ethnic groups (this would be seen by dragging the pointer on the slider to „Not FSM‟).

Figure 5 allows the direct comparison of pupils in the different ethnic groups, of those eligible for FSM and those who are not. This display is for boys and girls all together, but moving the slider will allow the performance of boys and girls to be considered separately.
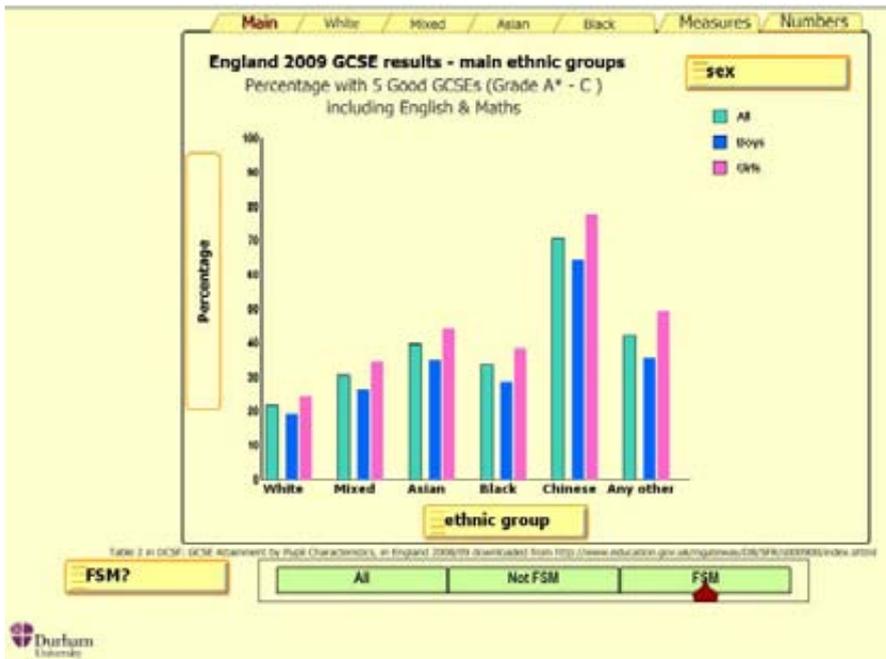
Figure 4: educational performance of pupils eligible for free school meals
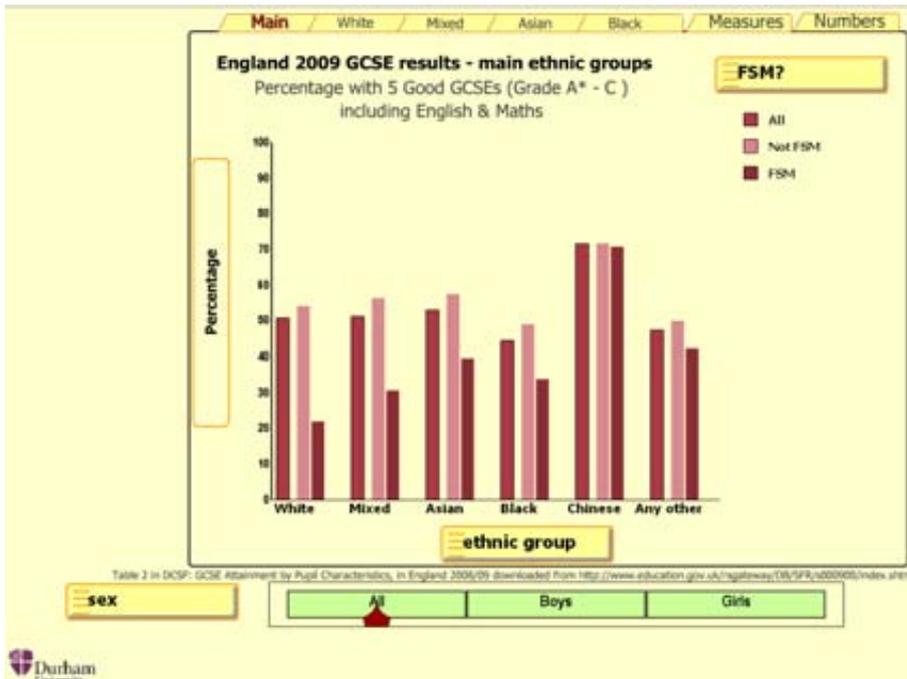
Figure 5: educational performance of pupils by eligibility for FSM and ethnicity

It can be seen that the statements from Ministers do not tell the whole story by any means: the White ethnic group are the largest group in the population by a very long way (83% of the total) but they are the only ethnic group for which the proportion achieving the government target who are eligible for FSM is less than half the proportion achieving the target who are not eligible for FSM.

Figure 6 shows the performance only of Chinese pupils. Figures 4 and 5 showed their performance was markedly higher than the performance of other ethnic groups, and this shows that the difference between the performance of pupils receiving FSM and those not receiving FSM is very small, for both boys and girls.

The last statement above by the Ministers singles out Chinese girls who are eligible for FSM as significantly outperforming the national average, but the same is true for Chinese boys – both compared with the average of all pupils, but more especially if compared only with boys.
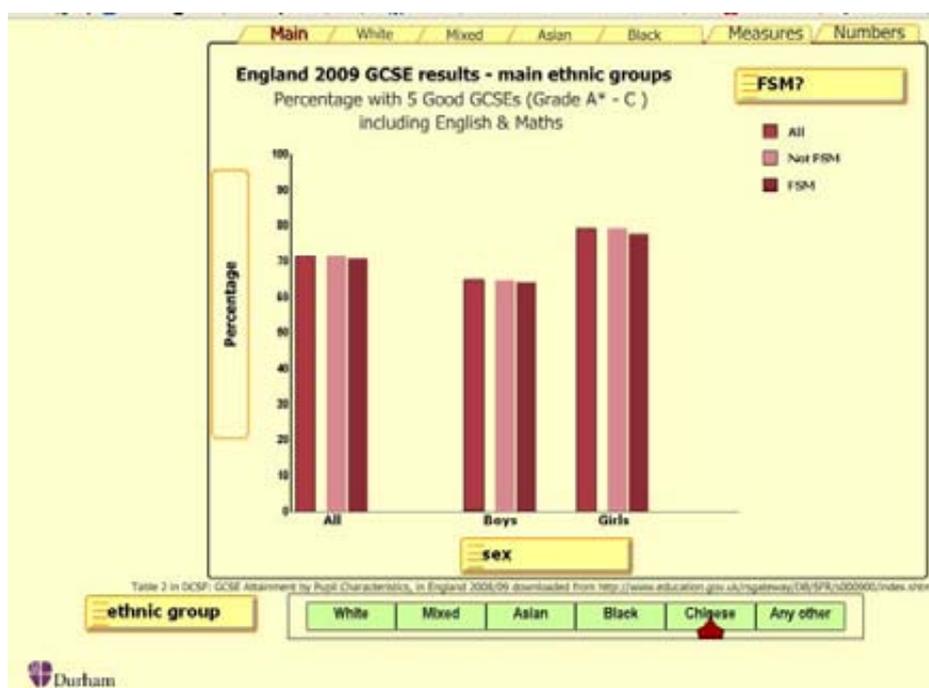
Figure 6: educational performance of Chinese pupils by eligibility for FSM and sex

Globalisation and the Internet

As with SL, there is no clear consensus about exactly what globalisation is, or even whether it is a positive or negative effect on balance. Most people would agree that globalisation has changed traditional patterns of trade, capital flows, migration and communications, but there has also been a transformation in the ways ideas are developed and communicated, how political movements gather momentum, and in the recognition that the earth faces a number of ecological challenges which will require international co-operation to meet.

Certainly the rapid development in modern communications systems has enabled the ordinary citizen in many countries to have a level of access to information which far outstrips their capacity to identify what information is most important to them, and to comprehend the implications of that information. One of the biggest challenges facing the world today is how to manage the information explosion so that the important does not get overwhelmed by the trivial.

The developments described earlier of the work being done by organisations like OECD, UNESCO etc., and by individuals like Rosling were initially a consequence of globalisation and are now an active force in driving further globalisation, with the internet as the most significant component of that evolvement.

OECD (2009) provides a good example of this paradigm shift: in recognition of the global challenges facing the world, OECD are seeking to develop new indicators of societal progress which recognise and encourage sustainable ecological practices, acknowledging that previous crude indicators such as purely economic measures have not served us well recently. High profile events such as this forum where nearly 2000 participants from over 100 countries included Nobel laureates as well as politicians, policy makers, academics, journalists and civil leaders are reported widely across the world. It also leaves a legacy of well-informed debate which is readily accessible through the internet and which should maintain a high position on rankings by internet search engines for some time to come. Similarly, The United Nations (2010, 2011) are committed to keeping the progress on the Millennium Goals in the public eye.

As that work goes forward, we need to find ways to engage with a much broader cross-section of the population than currently interact with complex data, and that means both finding ways to attract their attention to say „this is worth me making some effort to engage with" and also to enable them to make sense of the information and how it impacts on their life. We make some suggestions for components in that process in the next section.

Discussion

Our research in classrooms (e.g. Ridgway *et al* (2008)) shows that statistically naïve pupils can come to valid statistical conclusions about complex data when working with interactive displays. We believe that presenting data in this way will have a major influence on SL. We advocate the creation of interactive documents such as government policy documents, academic reviews, state-of-the-nation reviews, press releases and the like, in the form of mash-ups – a mixture of text and interactive display that allow users to explore data, test assertions, describe phenomena, and make conjectures of their own. The critical factor for enhancing SL is to have a variety of data sets that are inherently interesting (see the SMART Centre website for data visualisations on sex, drugs, alcohol and poverty). These data sets create a desire in the user to interpret then sensibly i.e. motivate a desire for SL. Mash-ups offer the facility to:

- provide argument and counterargument for and against rival accounts of the phenomena
- link to applets that demonstrate important statistical principles
- provide links to tutorial pages (especially with interactive displays)
- pose questions about data sets with answers. These can range from statements such as „it is wrong to say‟ through „these data are consistent with the following conjectures‟ to „these data strongly suggest that‟
- provide descriptions of metadata at different grain sizes – from explanations in non-technical language to full definitions.

Our work (e.g. Ridgway *et al* (2007)) has shown that some of the barriers to understanding complex evidence can be reduced and removed if data are presented in interactive multivariate displays. SL in the context of complex evidence requires a rather different assembly of competences than ones one might encounter in school statistics. There is a need to extend our conceptions of what it means to be statistically literate. Some key components are:

- ability to describe data surfaces – linear and non-linear relations, interactions, trends over time
- awareness of the importance of effect size (as opposed to „significance‟)
- knowledge of Simpson‟s paradox
- ability to critique study designs – from experimental designs through to surveys
- sophistication about measurement – ideas about reliability and validity, errors of measurement, bias, corruptibility of measures
- knowledge about the politics of data – the choice of measures is a political act

Conclusion

The world around us is full of uncertainty: to many observers it appears that the level of uncertainty is growing – recently the rate of occurrences of previously rare weather events seems to be much higher, though there is debate as to whether this is a result of global warming changing patterns of weather, or coincidence, or that communications and data gathering are now so much better than previously that we record much more of what is happening i.e. perhaps estimates of rates of occurrences were not so accurate.

Globalisation means that the human race is increasingly interdependent for its long-term survival and well-being, but encouraging co-operation across national and cultural boundaries has never been easy. Much has been done already to start raising awareness of key issues which require a much greater proportion of populations worldwide to be statistically literate than is currently the case. However, what it means to be statistically literate also needs to be understood much better, and how we might encourage the acquisition of SL skills across large sections of populations.

We have some evidence that naïve users can acquire important ideas such as effect size and interaction as a result of working with interactive data displays. We look forward to studying the development of the broader range of skills associated with SL set out above.

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RÉSUMÉ (ABSTRACT)

There is a movement towards increasing access to data, the development of dynamic displays, and evidence informed policy. A key challenge is to make data comprehensible by creating better displays and by increasing the overall level of statistical literacy (SL) in the adult population. Here, we argue that the only plausible mechanism for improving SL is to use the data sources themselves to educate users; we explore alternative approaches, challenges, and opportunities, with examples.

One approach is to provide links to statistics tutorials (e.g. http://nationalstrategies.standards.dcsf.gov.uk/node/169418). These seem (to us) unlikely to be much used. A second is to generate a general interest in interface design. The demise of swivel (www.swivel.com now inactive) can be attributed to the fact that interesting data displays populated with trivial and unordered data are unattractive. A third general approach is to build the acquisition of SL into the process of data exploration.

To develop SL, the data must be inherently interesting. Hans Rosling's approach provides a model of an excellent interface, a charismatic presenter, and data sets that relate to global changes that people actually want to understand. Some important aspects of this model are unlikely to be generally applicable in particular, videos on statistical issues that go viral.

The paper presents a variety of interfaces, and explores some approaches to embedded SL education. SMART Centre interfaces provide interactive displays and provocative questions; nave users have been shown to demonstrate good statistical insights.

We also explore the idea that a hierarchy of heuristics can be created for novices at different levels of statistical sophistication which lead to judgments that a professional statistician would agree with (see Wild, Pfannkuch, Regan and Horton (2011)).