How to Improve Statistical Literacy?

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Abstract

In the first part of the paper current initiatives and latest publications with several ideas and good practices for improving statistical literacy are highlighted. In the second part some recommendations for the main actors dealing with statistics are offered. These actors are: educational institutions, statistical offices and other statistical institutions, statistical societies and media. It is pointed out that the cooperation of these actors is essential for improving statistical literacy.

1   Introduction

At the beginning of the twentieth century H. G. Wells wrote: "Statistical thinking will one day be as necessary for efficient citizenship as the ability to read and write". How true! Lancaster (2011) concluded in *How Statistical Literacy, Official Statistics and Self-directed Learning Shaped Social Enquiry in the 19th and Early 20th Centuries* that we are still striving to achieve this in the modern technological age of the twenty-first century. Understanding statistical concepts and methodologies is essential for the proper and efficient use of statistical data collected and published by statistical offices and other authorised institutions. To ensure the better use of statistical data much effort must be put into improving statistical literacy in society.

2   What is statistical literacy?

While there are several definitions of statistical literacy, most are based on the definition given by Katherine K. Wallman (1993) in the speech she delivered when she became President of the American Statistical Association: "Statistical literacy is the ability to understand and critically evaluate statistical results that permeate our daily lives – coupled with the ability to appreciate the contributions that statistical thinking can make in public and private, professional and personal decisions".

Gal (2002) introduced two components of adult statistical literacy: knowledge elements and dispositional elements. The former deals with people's ability to interpret and critically evaluate statistical information, data-related arguments or stochastic phenomena they may encounter in diverse contexts, and when relevant. The latter component deals

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with their ability to discuss or communicate their reactions to such statistical information, such as their understanding of the meaning of the information, their opinions on the implications of this information, or their concerns regarding the acceptability of given conclusions.

Ben-Zvi and Garfield (2004) distinguish between statistical literacy, statistical reasoning, and statistical thinking. They point out that statistical literacy provides the foundation for reasoning and thinking: basic statistical knowledge makes it possible to reason with statistical ideas and to make sense of statistical information. For Ben-Zvi and Garfield, statistical literacy involves understanding and using the basic language and tools of statistics, while statistical reasoning is the way people reason with statistical ideas and make sense of statistical information. On the other side, statistical thinking involves a higher order of thinking than statistical reasoning. Ben-Zvi and Garfield view statistical thinking as the normative use of statistical models, methods and applications in considering or solving statistical problems. It is the way professional statisticians think.

Statistical literacy was also defined by the *W.M. Keck Statistical Literacy Project* as: (1) critical thinking about numbers, about statistics used as evidence in arguments; (2) the ability to read and interpret numbers in statements, surveys, tables and graphs; and (3) the study of how statistical associations are used as evidence of causal connections (Mittag, 2010).

Several attempts have been made to measure statistical literacy. A very complex study by Watson and Callingham (2003) assumed that statistical literacy is a hierarchical construct. Their analysis of a large archival database of over 3000 school students using Rasch analysis supported the hypothesis of a unidimensional construct and suggested six levels of understanding: (1) *idiosyncratic* engagement with context, tautological use of terminology and basic skills associated with one-to-one counting and reading cell values and tables; (2) *informal* engagement with context often reflecting intuitive non-statistical beliefs, single elements of complex terminology and settings, and basic one-step straightforward table, graph, and chance calculations; (3) *inconsistent* engagement with context, appropriate recognition of conclusions but without justification, and qualitative rather than quantitative use of statistical ideas; (4) *consistent non-critical* engagement with context, multiple aspects of terminology usage, appreciation of variation in chance settings only, and statistical skills associated with the mean, simple probabilities, and graph characteristics; (5) *critical*, questioning engagement in familiar and unfamiliar contexts that do not involve proportional reasoning, but which do involve appropriate use of terminology, qualitative interpretation of chance, and appreciation of variation; and (6) *critical mathematical* engagement with context, using proportional reasoning particularly in chance contexts, showing appreciation of the need for uncertainty in making predictions, and interpreting subtle aspects of language.

3   Current initiatives

Many (international) institutions, e.g., the International Association for Statistical Education (IASE), the United Nations Economic Commission for Europe (UNECE), educational institutions, statistical offices, statistical societies and associations, are dealing with how to improve statistical literacy. The most important is the *International Statistical Lit-*

eracy Project (ISLP, `http://iase-web.org/islp/About.php`), being carried out by the International Association for Statistical Education (IASE), the education section of the International Statistical Institute (ISI). It is the only international organisation whose focus is to promote national programmes and strives to increase the statistical literacy of all members of society. This project has concentrated on advancing statistical literacy among secondary school-age students via several activities, including a statistical literacy competition with the aim of bringing the use and understanding of statistics into teaching in a natural way. With various resources and activities assisted by international experts, the ISLP is running a very successful campaign across the continents. In recent years, the ISLP aim has been to extend teaching of statistical literacy to other spheres of life as well. The main target groups defined are as follows: citizens and the media, educational institutions (secondary school and upper secondary school-age students), universities and research institutions, decision-makers, libraries, and national statistical agencies. The perspective of the last target group is "how to bring promotion of statistical literacy more visibly on the agenda of all national statistical agencies". (See the Strategy Project of the ISLP: `http://iase-web.org/islp/Activities.php?p=Strategy_Project`.)

The United Nations Economic Commission for Europe (UNECE) has taken the notion of statistical literacy as the subject of its fourth guide to making data meaningful. As part of the work programme of the Conference of European Statisticians, a Steering Group on Statistical Dissemination and Communication organises annual Work Sessions that are supported by the UNECE Secretariat. The Steering Group aims to promote good practices in statistical organisations' dissemination and communication of information. The last Work Session on the Communication of Statistics was held in Geneva on 18-20 June 2014. In his talk on *Enabling your Stakeholders to use Statistics*, the keynote speaker Georges-Simon Ulrich, director general of the Swiss Federal Statistical Office, highlighted the importance of having a user-driven approach in National Statistical Offices (NSOs) to identify stakeholders with the goal to help them understand the ways the data are collected and to help them use statistics properly. He also stressed the importance of educating journalists and the public about statistics by improving statistical literacy. Four sessions were organised: Statistical literacy; Communication with respondents and evaluation of communication campaigns; Quick wins on low and zero budgets; and Good practices in electronic publications. Representatives of different countries presented their efforts to improve statistical literacy in their countries in the session on statistical literacy. The Austrian representative presented a project to improve statistical literacy in schools. The Canadian representative talked about a strategy that combines traditional and innovative communication practices to improve the accuracy of media coverage of the Canadian economy and society. The U.S. representatives presented the international programme *Census at School* that provides educators, students and families with an understanding of the relevance and importance of the Census. A presentation on behalf of the U.S. Census Bureau was about a variety of information tools and presentation methods in their communication efforts. The key motivation is to be able to meet the needs of the many audiences that consume statistical information. The need to constantly adapt to rapidly changing technology to deliver information was stressed. The representative from the Netherlands presented efforts and strategies for how to reach young users of statistics. The Latvian representative presented the project called *School Corner* to promote the

understanding of statistical data and proper usage of data among pupils in secondary schools. In addition, in the other three sessions some important issues for improving statistical literacy were discussed.

Several other international and national projects are also related to statistical literacy. One of these is the *W.M. Keck Statistical Literacy Project* at Augsburg College in the U.S.A. The project's primary goal is to present statistical literacy as an interdisciplinary activity. As such, it has overlaps with quantitative reasoning, quantitative literacy, numeracy, and statistical reasoning. A second goal is to present statistical literacy as the study of statisticians in everyday arguments. Milo Schield directs the project and is also the webmaster of Statistical Literacy on the Web (`www.StatLit.org`), a key site for articles, books and activities related to statistical literacy.

Two established projects, *CensusAtSchool* and *ExperimentsAtSchool*, collect data from school-aged learners and this motivates students to analyse the data, and teachers to teach statistics in an exciting way.

A EU-funded project seeking to promote statistical literacy amongst young people by providing an innovative e-course involved the National Statistical Offices of Malta and Finland and the University of Hagen in Germany. The primary goal was to encourage international cooperation between statistical agencies and educational institutions to promote statistical literacy (Mittag, 2010). The main result of this project is a freely available *eCourse in Statistics* with the clear objective of fostering statistical literacy among both the local and international community of statistical users (`http://www.fernuni-hagen.de/statliteracy/`).

Many presentations at the International Conferences on Teaching Statistics (ICOTS) deal with statistical literacy. At the ICOTS 2014 conference, a special topic on *Statistical Literacy in Wider Society* was organised, featuring many presentations. The goal of the topic was "to develop sustainable initiatives which enable citizens to lead and extend debates, in the media and elsewhere, on issues of inequality, crime, effects of smoking, use of alcohol, and support for societal preferences. This democratic imperative leads us to questions such as: How can we encourage people to want to engage in statistical learning? How can we contribute to subject-specific learning of relevant statistical knowledge? How do we enrich our understanding of statistical literacy and methods by which it can be attained and sustained? These invited sessions seek to explore and enrich a variety of effective practices and interventions" (`http://icots.info/9/topic.php?t=7`).

In addition, statistical societies are active in promoting the public understanding of statistics. The Royal Statistical Society launched a ten-year statistical literacy campaign in 2010. Several statistical societies are giving awards to journalists for their correct use of statistical data.

In the last few decades, there has been a greater number of publications dealing with statistical literacy issues. These include the following. In 2004 Ben-Zvi and Garfield edited a very important book dealing with statistical literacy *The Challenge of Developing Statistical Literacy, Reasoning and Thinking*. The editors' aim was to provide a useful resource for educators and researchers interested in helping students at all educational levels to develop statistical literacy. The meetings leading up to the book were the Fifth International Conference on Teaching Statistics (ICOTS-5) in 1998, the first, second and third International Research Forum on Statistical Reasoning, Thinking, and Literacy (SRTL_1,2,3) held in 1999, 2001 and 2003 respectively. Selected papers are included

in the resulting book. The first chapter provides basic definitions of statistical literacy, reasoning and thinking. The next four chapters provide an overview of these topics from historical, psychological, and educational perspectives. In the following chapters, particular types of statistical reasoning with key practical implications related to instruction, assessment and research are discussed. The last chapter describes the current state of statistics education research, and implications for teaching statistics.

The former director of the ISLP, Juana Sanchez edited the book *Government Statistical Offices and Statistical Literacy* in 2008. The book's objective was "to explain the process to the emergence of successful, currently active, programs of NSOs to educate the general public in statistics". The editor invited authors committed to improving of statistical literacy in their countries and who had been managing the programmes for a long time, meaning that these programmes reached the front page of the NSOs' web-pages and thereby outside learners and the general public. Authors from NSOs from Portugal, New Zealand, Italy, Finland, Australia and Canada were invited to present good practices for improving statistical literacy in their countries. The goal of the editor and the authors was to encourage other NSOs that had discontinued or never even started programmes on statistical literacy.

A special issue on statistical literacy was published in the *Statistical Journal of the IAOS* in 2011. Beside papers presenting innovative teaching methods to improve statistical literacy, it included papers dealing with innovative work programmes and initiatives in NSOs to improve statistical literacy and the statistical literacy need of different segments of the community. Forbes et al. describe how Statistics New Zealand provides products that support the interpretation of the data they produce for schools, universities and the general public. Townsend argues that educating the public about the world of data can help raise the profile of NSOs in the public mind. Statistics Canada provides outreach and resources designed to improve statistical literacy, working with teachers and students of statistics. Helenius and Mikkela argue that NSOs need to promote statistical literacy in society, with the added consequence of maintaining the legitimacy of NSOs in society. They provide good practices of co-operation between an NSO and various user groups (e.g., the media, educational institutes, members of parliament and citizens). Sanchez et al. argue that NSOs must become more involved in the promotion of statistical literacy, and work together with national statistical societies, international organisations as the ISLP, and national educational institutions stakeholders that share an interest in promoting statistical literacy in different segments of society. Similarly, Gal and Murray pointed out that "improving the effectiveness of information products and services created by statistics agencies requires awareness of four general issues: the factors that affect the difficulty of finding and comprehending statistical products and services, the nature of clients' statistical literacy, the existence of individual or group differences in statistical literacy; and the information needs of different customer groups".

4 Who can contribute to better statistical literacy, and how?

As mentioned, several actors are able to contribute to better statistical literacy, e.g., educational institutions, statistical offices, statistical associations, and the media. The more these various actors cooperate in the efforts to improve statistical literacy, the better the results. In the above overview of the current initiatives and main publications seeking to improve statistical literacy, many ideas and good practices were mentioned. Here, some recommendations based on these ideas are suggested for different actors.

4.1 Educational institutions

Ruth Carver, the president of the American Statistical Association, pointed out in her presidential message entitled *Statistical Literacy and the 2013 International Year of Statistics* that "statistical literacy can no longer be viewed as a skill needed by a select few; it is essential knowledge required by all that must be developed beginning at an early age and built on throughout one's school years", and later in her message "to reach the goal of a statistically literate citizenry, it is crucial for teachers at all levels to be statistically literate themselves and to possess the pedagogical tools necessary to provide quality learning experiences that develop and deepen their students' statistical understanding" (`http://www.statlit.org/pdf/2012-ASA-Presidents-Message-Statistical-Literacy.pdf`). It is essential that properly educated statisticians teach statistics at all educational levels, from elementary to doctoral. There are still some European countries that have no university programmes on statistics at any level. Also in Slovenia there is no undergraduate programme on statistics, although such education at the master's and doctoral level has been provided for the last 12 years. At least in the European case, some help from European statistical institutions would be appreciated in establishing appropriate statistical programmes. Special attention should also be paid to master's and doctoral programmes on official statistics that target a very important segment of professional government statisticians whose work is essential for policy decision-makers and the segment of professional positions in a wide range of organisations and companies conducting large-scale statistical work.

A lot of effort to impart statistical knowledge to improve statistical literacy on lower levels of education is entailed in different international projects as previously mentioned (e.g., ISLP, *CensusAtSchool*, *ExperimentsAtSchool*). It is important that representatives (individuals or institutions) of as many countries as possible collaborate in these projects. It is especially important to use these very good, internationally developed tools to improve statistical literacy at lower education levels, although they are unfortunately frequently only published in the English language. Therefore, the results of these projects should be appropriately translated into their own languages and promoted to the educational institutions in their countries.

Educational institutions (together with statistical institutions and statistical associations) have to organise meetings, seminars and public discussions for statistics teachers at all education levels to harmonise the statistical terminology used, to logically link statistical topics at different levels of education etc. It is crucial that the individuals and

institutions preparing and implementing statistical courses and programmes at all education levels (from elementary school to doctoral programmes) cooperate with each other. It is important to establish organisational ways to control whether there are problems in the statistical education in the education system at all levels, e.g., if certain topics in statistics are missing on a particular level, too much overlap within and between levels, too difficult for a given level of students, a lack of connections with the data producers, or if the lecturers are appropriately educated.

4.2   Statistical Offices and other statistical institutions

It is encouraging that in the last decade National Statistical Offices (NSOs) have shown their stronger awareness of statistical literacy. As mentioned above, several initiatives for improving statistical literacy have been proposed by some NSOs that can also be implemented by the other NSOs. Statistical institutions can transmit the statistical knowledge about the data they collect, the methodologies they use, possible methods to analyse the data, typical abuses or misunderstandings of statistical concepts and data etc. to different segments of users (e.g., business enterprises, governmental sector, researchers, students, the general public, journalists) directly or via the media.

The direct approaches could include:

- the publication of brief and easy-to-read information on the most visible webpages (e.g., webpages of NSOs, statistical associations, educational institutions that organise programmes on statistics) and in different media concerning selected statistical methodologies or data or statistical activities (e.g., information on data sources, why and how they were obtained);

- advising different segments of the population separately about the proper use and interpretation of statistical data;

- organising seminars for different segments of users of statistical data on selected statistical topics for a better understanding of statistical results; and

- the presentation of typical abuses or misunderstandings of statistical concepts and data.

Very important communication with different population segments, especially the adult population, to improve statistical literacy can also be achieved with the help of traditional and especially new media (e.g., the Internet and social media). As Gabrielle Beaudoin stressed at the last Work Session on the Communication of Statistics organised by the Conference of European Statisticians (UNECE), "... Statistics Canada has adopted a strategy that combines traditional and innovative communication practices, with the goal of expanding coverage and improving the accuracy of media coverage about the Canadian economy and society" and later "The proactive, multi-channel approach (was) adopted by the agency to educate journalists and be more responsive to their needs. Media relations activities span from determining the content and style of statistical releases, to hosting concept brief sessions and media lockups, up to training spokespersons and publishing new media content to increase Canadians' understanding of the state of the country".

Several other NSOs have developed a similar good relationships with the media (e.g., Statistics New Zealand, see Harraway and Forbes, 2013), but many of them still do not use the media enough to promote statistical literacy to different segments of the population. Of course, the experience of Statistics Canada with the media is very useful and is recommended to be followed by other statistical institutions, especially NSOs.

As mentioned, journalists have to be properly statistically educated and, to achieve this, there must be cooperation of NSOs and other statistical institutions, educational institutions and statistical associations with the media. There are many ways for achieving this goal. One possibility is to take advantage of an NSO's regular meetings at the end of each month with the media where they present information on the socio-economic indicators of the country. These meetings could be used for a short 'educational' purpose to ensure a proper understanding of the statistical concepts and data, along with examples of misunderstanding. Linking NSOs and other authorised institutions with the users of statistical data could also lead to a better understanding of which data are needed and facilitate searching for better solutions for the planning of statistical data collection, processing and publication. A good example of such cooperation with users was established at the Statistical Office of the Republic of Slovenia (SORS) many years ago. It established 23 statistical advisory committees with around 400 non-SORS members and about 100 SORS members for individual fields of national statistics where experts from different users institutions together with representatives of the statistical office put in a lot of effort to discuss which data are missing, which are no longer relevant, about how to provide quality, timely and relevant statistics.

4.3   Statistical societies

The main task of a statistical society is to link various actors (e.g., educational institutions, statistical offices, and the media) and to provide more harmonised efforts for improving statistical literacy. Many national statistical societies are providing awards for good practices of the correct transmission/publication of statistical concepts and data, e.g., awarding journalists for helping the statistical community to improve statistical literacy among different population segments. This practice is also recommended to those societies that have not yet introduced it.

5   Conclusion

Statistical literacy has received growing attention in the last decades. In earlier decades, most of the work on statistical education was done in primary and secondary schools with a focus on statistical literacy, statistical reasoning, and statistical thinking. Yet only in the last decade NSOs' awareness of statistical literacy has been present. Some NSOs have shown a broader responsibility than the mere production of data. They are increasingly proactive in improving statistical literacy and making data more accessible. There are also several actions by other statistical institutions, statistical societies and education institutions to improve statistical literacy but a lot remains to be done in the future to improve the statistical literacy of different segments of the population. The cooperation of

all actors dealing with statistics, especially between NSOs and academics, is important for hastening the process of improving statistical literacy.

Acknowledgements

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