

ProCivicStat Report 2018

Engaging Civic Statistics: A Call for Action and Recommendations



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Abstract: This report presents six recommendations that aim to promote the field of civic statistics and improve the critical understanding of statistics and quantitative evidence relevant to burning social issues which is provided to the public by the media, official statistics offices, and other data providers. Effective citizen engagement with social issues requires active participation and a broad range of skills, including the understanding of data and statistics about social issues. Yet, many statistics classes and educational curricula are not designed to teach relevant skills and improve learners' statistical literacy, despite the importance of engaging learners and future citizens with data about social issues and their connections to social policy. We outline unique characteristics of civic statistics and illustrate the approaches needed to teach and promote the knowledge, skills, dispositions, and enabling processes associated with critical understanding of statistics and texts about the social and economic well-being of societies. We also discuss ideas regarding development of curricula and educational resources, use of emerging technologies, teachers and teaching approaches, sources for relevant datasets and texts about civic statistics, future research, assessment, collaborations between different stakeholders, and other issues.

Background: This report is based on the work of *ProCivicStat* (PCS), a project focused on promoting civic engagement via exploration of evidence and on related challenges for statistics education. PCS is a 3-year strategic partnership, Sept 2015-Sept 2018, funded by the ERASMUS+ program of the European Commission. PCS involves teams from six academic institutions in five countries: the universities of Durham (UK), Haifa (Israel), Ludwigsburg (Germany), Paderborn (Germany), Porto (Portugal) and Szeged (Hungary). A list of all ProCivicStat partners appears in Annex D.



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For more information, extensive teaching resources, supporting papers, datasets, contacts, and our Call for Action and Recommendations: See the ProCivicStat website under the International Association for Statistics Education (IASE) website here: <http://iase-web.org/islp/pcs>. You can also visit our original website at www.procivicstat.org, though it will not be updated after Nov 2018.

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Executive summary and key recommendations

1. The challenges, in a nutshell: This report aims to promote educational actions and a systemic change related to the need to develop knowledge, skills, and attitudes that underlie the understanding of *civic statistics*, i.e., statistics about important societal trends and about topics that matter to the social and economic well-being of citizens.

Our overarching goal is to promote civic engagement among (young) citizens by improving their understanding of statistics about burning social issues. We assume that citizens need to be aware of and critically understand statistics regarding past trends, present situations, and possible future changes in key social and economic areas such as demographics, employment, wages, migration, health, crime, poverty, access to services, education, human rights, and public expenditures.

Unfortunately, traditional statistics courses do not focus on issues that are at the heart of understanding civic statistics, and seldom connect learners with important social issues. Hence, there is an urgent need to rethink current educational approaches in this regard, and create new types of resources.

2. Stakeholders: This report presents a call for action and recommendations to the many stakeholders engaged in formal statistics education at the college/tertiary or high-school levels, or who are involved or interested in fostering the statistical literacy of citizens. These stakeholders includes educators at all levels, school and university administrators, policy makers, official statistics providers, researchers, media professionals, teacher trainers, data scientists, software developers, and many others.

3. Key recommendations: To address the challenges sketched above, the ProCivicStat partners present six key recommendations. These are listed in Table 1 and amplified in Part 4 later in this report, after the background and key issues have been explained and illustrated in more detail.

Table 1: Six key recommendations by ProCivicStat partners

#1	Statistics education activities should promote engagement with social issues and develop learners' critical understanding of statistics about key civic phenomena.
#2	Use relevant data and texts, and highlight the multivariate, dynamic and aggregated nature of social phenomena.
#3	Embrace technologies that enable rich visualizations and interactions with data about relevant social phenomena.
#4	Teaching methods should develop skills of critical interpretation of a wide variety of data and text sources.
#5	Assessments should examine the ability to investigate and critically understand data, statistics findings and messages about key social phenomena.
#6	Promoting the understanding of civic statistics requires a systemic change and collaboration by relevant stakeholders.

Aufruf zum Handeln und bildungspolitische Empfehlungen: Zusammenfassung

1. Die Herausforderungen in Kürze: Ziel dieses Berichts ist die Förderung von Bildungsmaßnahmen und systemischen Veränderungen im Zusammenhang mit der Entwicklung von Kenntnissen, Fähigkeiten und Einstellungen, die dem Verständnis von *Zivilstatistik* zugrunde liegen, d.h. Statistiken über wichtige gesellschaftliche Entwicklungen, Trends und Themen, die für das soziale und wirtschaftliche Wohlergehen der Bürger von Bedeutung sind.

Unser übergeordnetes Ziel ist es, das bürgerschaftliche Engagement von (jungen) Bürgern zu fördern, indem sie ihr Verständnis von Statistik zu brennenden sozialen Problemen verbessern. Wir gehen davon aus, dass Bürger Statistiken über vergangene Trends, gegenwärtige Situationen und mögliche zukünftige Veränderungen in wichtigen sozialen und wirtschaftlichen Bereichen wie Demografie, Beschäftigung, Löhne, Migration, Gesundheit, Kriminalität, Armut, Zugang zu Dienstleistungen, Menschenrechten und öffentlichen Ausgaben kennen und kritisch verstehen müssen.

Leider konzentrieren sich traditionelle Statistikurse nicht auf Fragen, die im Zentrum des Verständnisses von Zivilstatistik stehen und verbinden selten Lerninhalte mit wichtigen sozialen Problemen. Daher besteht ein dringender Bedarf, die aktuellen pädagogischen Ansätze in dieser Hinsicht zu überdenken und neue Arten von Ressourcen zu schaffen.

2. Interessengruppen: Dieser Bericht enthält einen Aufruf zum Handeln und Empfehlungen für zahlreiche Interessengruppen, die sich mit statistischer Bildung im Hochschul- oder Sekundarbereich befassen oder die statistische Kompetenz der Bürger fördern. Zu diesen Akteuren gehören Pädagogen auf allen Ebenen, Schul- und Universitätsadministratoren, politische Entscheidungsträger, offizielle Statistikanbieter, Forscher, Medienfachleute, Lehrerausbilder, Datenwissenschaftler, Softwareentwickler und viele andere.

3. Empfehlungen: Um den oben skizzierten Herausforderungen zu begegnen, präsentieren die ProCivicStat-Partner sechs Schlüsselempfehlungen. Diese sind in Tabelle 1 und später in diesem Bericht in Teil 4 aufgeführt, nachdem Hintergründe näher erläutert und dargestellt wurden.

Tabelle 1: Sechs Schlüsselempfehlungen von den ProCivicStat-Partnern

#1	Bildungsaktivitäten in Statistik sollen die Auseinandersetzung mit sozialen Themen fördern und das kritische Verständnis der Lernenden für Statistiken zu wichtigen gesellschaftlichen Phänomene entwickeln.
#2	Verwenden Sie relevante Daten und Texte und heben Sie die multivariate, dynamische und aggregierte Natur sozialer Phänomene hervor.
#3	Setzen Sie Software ein, die umfangreiche Visualisierungen und Interaktionen mit Daten über relevante soziale Phänomene ermöglichen.
#4	Lehrmethoden sollen Fähigkeiten zur kritischen Interpretation einer Vielzahl von Daten- und Textquellen entwickeln.
#5	Assessments sollten die Fähigkeit überprüfen, Daten, statistische Befunde und Nachrichten zu wichtigen sozialen Phänomenen zu untersuchen und kritisch zu verstehen.
#6	Die Förderung des Verständnisses von Zivilstatistiken erfordert eine systemische Veränderung und die Zusammenarbeit relevanter Akteure.

Part 1:

The case for civic statistics, and their unique features

4. Citizen engagement with civic issues. Knowledge and skills to reason adequately with data are an important prerequisite for the functioning of democracy in modern societies. For example, in a society that aims to keep up with promises of equity and fairness, questions on the extent to which social groups (e.g., women, minorities, elderly, people with disabilities, etc.) are disadvantaged in their career options, wages, or access to education or to public services, have to be judged largely on a quantitative level and this requires access to evidence and statistical knowledge.

Further, in an increasingly complex world, hearing citizens' opinions is critical for good policy-making at the national and local levels; making and implementing decisions on controversial social topics depends on citizens' consent and support. As OECD (2009) argues, unless citizens understand and are engaged in decisions, trust in political decision making is easily lost. Hence, education about civic statistics aims to contribute to citizen engagement and empowerment (Schiller & Engel, 2017).

5. The problems – educational and knowledge gaps. To achieve the goal of citizen engagement it is necessary to equip learners both at the high-school level and the university/tertiary level, as well as adults in general, with the knowledge, skills, and attitudes needed to understand relevant data and engage with the statistics involved. Yet, "citizen engagement" as well as "understanding statistics about society" does not have a natural home in educational systems, broadly viewed.

At the *high-school level* and before that at the *middle-school level*, the knowledge, skills, and dispositions required are either distributed among multiple school subjects (Nicholson, Ridgway and McCusker, 2013), or perhaps more often not addressed well by any school subject. Teaching for "understanding statistics about society" does not fit traditional notions of what should be covered at the high-school level, where statistics are mainly subsumed within mathematics education, and only infrequently in other school subjects (Callingham & Watson, 2017).

At the *university or tertiary level*, similar concerns may apply, since at this level most students are exposed to statistics in a single introductory statistics course. Traditional introductory statistics curricula have been focused on data analysis issues and the acquisition of knowledge and skills related to performing various statistical procedures and interpreting their results.

Indeed, over several decades we have seen calls to infuse introductory statistics with work on real data and other efforts to refresh the traditional introductory class (GAISE, 2016 is one of the latest calls). However, in our view there is a big difference between using "real" data per se and involving students with work on "real civic statistics". For many teachers, "real" data mean nothing more than using small datasets stemming from local surveys or academic research, or even artificially made data, with little or no social context. In contrast, civic statistics involves findings, reports, or raw datasets — but all of them related to and stemming from socially meaningful issues of concern to citizens and policy makers.

6. More about civic statistics and their data sources. Civic statistics have been traditionally generated mainly by official statistics offices and other public and multilateral or international agencies. Such actors usually collect large-scale data based on administrative records, large-scale surveys, census studies, and related sources. However in recent years, some NGOs and advocacy groups generate their own data or statistical reports regarding civic topics of interest to them.

In addition, some commercial companies, and some official statistics offices, use “big data” to shed light on civic phenomena. This implies that understanding civic statistics may increasingly require some familiarity with ideas from the emerging field of Data Science (Engel, 2017). Overall, citizens have access to more data and findings than ever about civic issues, given the increasing availability of open data sources, both from public and private sources.

7. Public encounters with civic statistics. The “food chain” related to civic statistics is a complex one, and does not stop with discussing data sources or datasets. As noted above, official statistics offices are the primary producers of data and reports about civic statistics. However, their findings, reports and data-based messages about civic phenomena usually do not reach the public directly but are *mediated or re-distributed* to the public via multiple channels. Examples are: print media (e.g., articles in newspapers and magazines), visual media (e.g., TV broadcasts, adverts and brochures), digital media (e.g., texts and files on websites, blogs), discussions on social networks, etc. These and other publication channels are used by a range of public and private stakeholders that also include bloggers, think-tanks and research institutes, advocacy groups, various NGOs, and other players (e.g., Gapminder) without the involvement of the original producers.

So citizens are exposed to a very wide variety of information sources; teaching about civic statistics should both reflect and engage this variety of sources. Learners, should learn to deconstruct the diverse rhetorical and argumentative styles they encounter when reading and interpreting statistical messages from such sources, as well as be able to generate their own messages, and if needed conduct their own analysis of available data.

8. The unique features of civic statistics. Based on our analysis of information from various providers of civic statistics, and our review of the literature, we argue that civic statistics involve data or materials that have six distinctive features: they are often *multivariate*, *aggregate*, *dynamic*, and communicated through *rich text* and *data visualizations*, and *embedded in a social context*. These features are explained below and illustrated via the examples in Figure 1 and Figure 2. These features are highlighted in this report because they are usually not at the core of regular statistics instruction, but are critical for civic statistics.

- ***Multivariate phenomena.*** Data about social variables usually do not stand in isolation; their description and understanding involves other variables that are *correlated*, *interact with each other*, or have *non-linear* relationships with each other. This point has been emphasized by various authors though in different ways. The GAISE 2016 recommendations for college instructors in statistics, for instance, reiterates a well known claim that phenomena in the modern world co-vary, i.e. a phenomenon of interest is affected or caused by other variables or factors, and in turn interacts with or affects other phenomena. However, many

social phenomena co-vary, yet in a non-linear fashion, making it challenging to describe and in turn understand what depends on what.

- **Aggregated data.** Statistics about societal phenomena are often reported not with regard to continuous raw variables *per se*, but involve data that are grouped in diverse ways, sometimes using qualitative variables that have nominal groups (e.g., men vs. women) or form ordinal levels (e.g., primary, secondary, or tertiary education) (Ograjenšek and Gal, 2016). Further, data are often reported for multiple subgroups at different levels of aggregation, such as by breaking them down for subgroups, easily leading to 3-way, 4-way, or 5-way categorizations. The citizen is expected to understand that what we know about the phenomena of interest depends on the level of aggregation, i.e., the patterns may well change as we aggregate or disaggregate the statistic within any subgroups of a variable or factor deemed relevant.

Further, statistics providers create key messages to decision makers and to the general public regarding levels or changes in hundreds of *indicators*, such as unemployment levels, child mortality, or income inequality. These and many other indicators are often not raw variables, such as those encountered in introductory statistics, but rather combinations of data elements that may be expressed as percentages, ratios, or numbers on arbitrary scales (e.g., consumer price index, Gini coefficient). Such indices may be computed as simple rates, or be derived as complex aggregates of weighted elements. They may be based either on objective (e.g., “consumer spending”) or subjective data (e.g., “consumer confidence”), and their definitions, underlying methodology, or modes of measurement may develop and change over time.

- **Dynamic data, that may be open to interpretation.** Civic statistics are often not the result of a one-time data collection effort (e.g., unlike a single survey discussed in an introductory statistics course) but often are based on multiple data sources. These may be data collected periodically through the same methodology (e.g., an employment survey each month or year) or reported a comparative basis (e.g., in multiple countries, as in statistics published by Eurostat, OECD, WHO, UNESCO, the World Bank, and many others). Consequently, data are often reported as a trend over time, and may be updated when new data become available or old data re-evaluated. Further, different stakeholders may provide different findings and messages regarding the *same* social phenomena (e.g., gender pay gap, crime rates among different social groups, people under the poverty line), or may use different indicators or levels of aggregation to analyze and communicate their findings.
- **The use of rich texts.** Statistical information about society is brought to the public mainly via *texts*. Official statistics providers are the primary producers of civic statistics and create a range of products such as press releases, briefs, analytic reports, or visualizations, yet the public seldom engages with them directly when they are released. Rather, civic statistics are often conveyed or mediated to the public through journalistic reporting in the print and visual media or via publications of private entities such as NGOs, advocacy groups, bloggers, etc. These “secondary players” (see Gal & Murray, 2011; Schiller & Engel; 2017) usually pick only selected aspects of the original publications or

findings, and may sometimes present them in ways that aim to advance specific points of view, hence require critical interpretation by readers and users.

All this implies that *text* is a primary medium for communication of statistics (Gal, 2002), especially regarding civic statistics; the public needs to comprehend and critically interpret different genres of writing, such as formal language used in official reports, journalistic writing, and more. However, text-based products or messages such as those mentioned above are often ignored by mathematics and statistics teachers, and students have few experiences working with the rich texts and persuasive data-related arguments used in discussions about important social issues.

- **Diverse visualizations.** Since data and findings about social phenomena (such as levels or changes in accident rates, income, unemployment or poverty, etc.) are multivariate, dynamic, and aggregated, their description across time or comparison units (e.g., regions, social groups) requires the use of diverse types of representations. Hence, users and readers nowadays encounter a range of static, dynamic, and interactive visualizations (Ridgway, 2016), or infographics that are much broader and more sophisticated compared to the limited range of graphs, histograms, and tables used in introductory statistics classes.
- **The social context of civic statistics.** Arguably, all statistics that are collected may be important for whoever collected them. However, civic statistics involve issues of importance to society at large or to large subgroups in it. Interpreting civic statistics requires attention to the broader world context (e.g., one cannot understand statistics about migration into Europe without being aware of the phenomenon of migration and its social significance). Understanding the meaning or societal importance of civic statistics, or their dynamic progression over time, requires familiarity with and sensitivity to a network of correlates, both antecedents (causal factors) and outcomes (consequences for individuals, communities, stakeholders, and society).

9. **Examples.** Here we describe two examples to illustrate how the basic characteristics of civic statistics manifest themselves in different types of messages or civic tasks.

Figure 1: News about poverty - press release from an official statistics agency

Press release, Statistics Portugal



At risk of poverty rate, in 2014-15

The 2015 EU Statistics on Income and Living Conditions survey provisional data on previous year incomes indicates that 19.5% of people were at risk of poverty in 2014, keeping the value of the previous year.

The risk of poverty for the elderly population has increased for the second consecutive year.

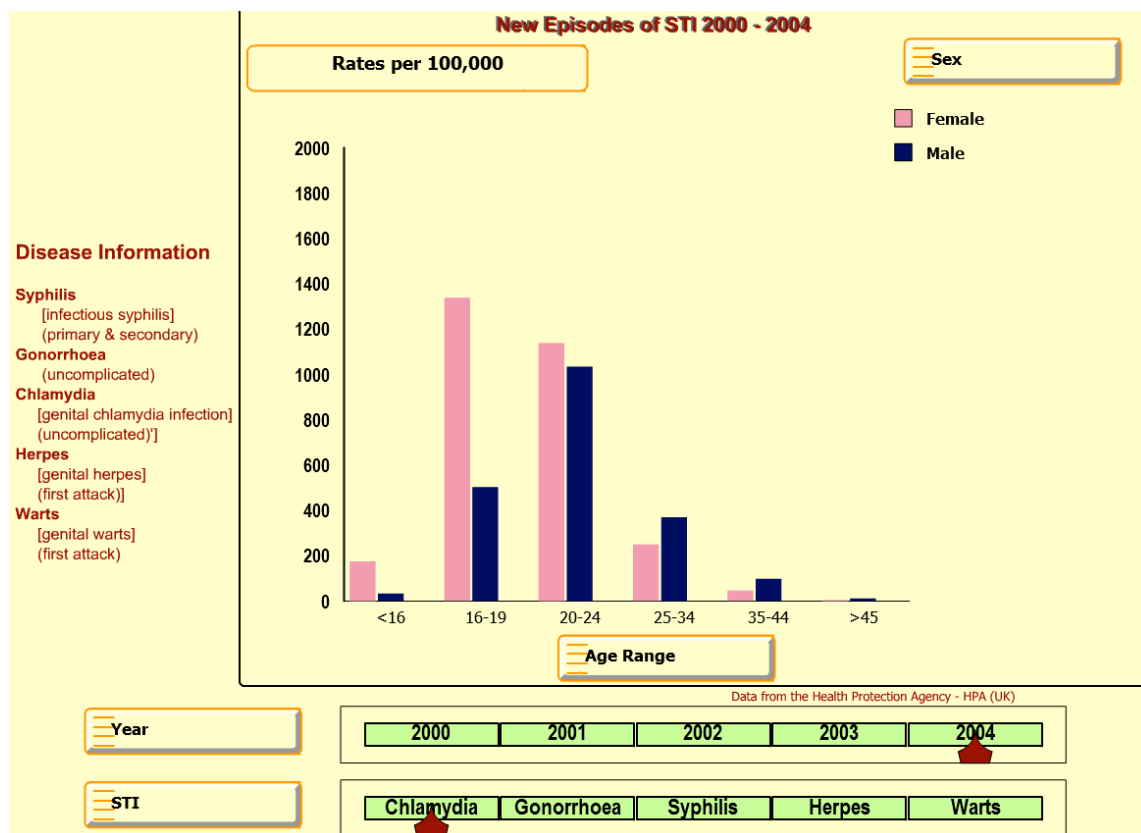
The presence of children in a household is associated to a higher risk of poverty, reaching 22.2% for households with dependent children vis-à-vis 16.7% for households without dependent children.

10. Figure 1 is an excerpt from a 1-page press release of an official statistics agency. Despite being brief, it illustrates several of the characteristics of civic statistics listed above. It shows, for instance, how the level of poverty cannot be described or understood by itself, without involving additional variables, such as age or the number of children in a household, how statistics change over time, and how text is a primary reporting medium.

11. Figure 2 is taken from a website of the SMART Centre at Durham University, UK, a PCS partner. It shows a screen shot of a (dynamic) visualization regarding trends in sexually transmitted diseases in the UK, over several years and in different age groups. You can interact with a dynamic version of this visualization here: www.dur.ac.uk/resources/smart.centre/Freeware/STI_GUM_update1.swf. The sliders at the bottom can be used to explore trends over time for different diseases or for males and females separately. Variable names can be dragged to different locations to create different graphs, and enable exploration of a range of functional relationships.

Dear reader - before continuing, please ask yourself: Which characteristics of civic statistics listed earlier are illustrated by the visualization in Figure 2?

*Figure 2: Trends in sexually transmitted diseases in the UK
(Screen shot from a dynamic visualization; Taken with permission from
<https://www.dur.ac.uk/smart.centre/freeware>)*



12. The visualization in Figure 2 illustrates several characteristics and demands of civic statistics, such as their multivariate and dynamic nature, the use of aggregations,

interactions between variables, and the importance of visualizations. The display in Figure 2 also illustrates the need for adults to be able to critically reflect on the origin (provenance) and quality of data, and how variables or social phenomena are defined and measured. For instance, in the case of sexually transmitted diseases, these data are national data collected from clinics – but people have to choose to go to a clinic before they appear in the data set, affecting representativeness of the data. Also, the data shown are several years old, hence users have to worry not only about sampling but also about the quality and currency of the data used.

13. What are the curriculum implications? These six characteristics of civic statistics show that civic statistics are situated in an information space that is more complex and multifaceted than the simplified data used in teaching introductory statistics. Understanding of civic statistics requires a broader and deeper knowledge base both of statistical techniques and research methods and of the contexts in which decisions are made about important social issues.

When interacting with civic statistics, citizens may need to understand that there is no definitive, single way to describe a social phenomenon of interest. They also need to adopt a questioning attitude and to know what questions to ask about the nature, limitations, or credibility of different data sources and statistical messages, even on the same topic. In contrast, the information and statistics that the learners of introductory statistics at the high-school or college level are exposed to are much more restricted.

14. Despite the actual cognitive demands of the tasks encompassed by or involving civic statistics, leading introductory textbooks we analyzed are devoted largely to technical mastery of conventional statistical topics, and do little to expose learners to important (yet accessible) statistical ideas are characteristics of civic statistics. As a result, curricula cannot equip students to engage with evidence-based arguments in public debates or to understand the broad range of topics and issues encompassed by civic statistics, and do not link data with "burning" social questions and societal contexts. This situation is paradoxical, because the teaching of introductory statistics often argues that a basic justification and a goal for teaching statistics is to prepare students for a data-rich world.

15. GAISE (2016) vs. civic statistics. To support the concerns listed above, we point the reader to the most recent Guidelines for Assessment and Instruction in Statistics Education at the college level (GAISE, 2016). These college-level guidelines present instructional principles with which we wholeheartedly agree, including but not limited to the need to teach statistics as an investigative process of problem-solving and decision-making, with an emphasis on giving students experience with multivariable thinking, integrating real data with a context and purpose, fostering active learning, using technology to explore concepts and analyze data, and using assessments to improve and evaluate student learning. Some of these ideas appear consistent with the points we raised above about the multivariate and dynamic nature of civic statistics. However, virtually all the practical *examples* provided in GAISE 2016 for the use of real data and for connecting with content and purpose appear to us to fall short when it comes to connecting statistics with contextualized issues and do not include elements that can help student engagement with civic issues.

We analyzed the 43 items used in the GAISE 2016 College Report to illustrate good tasks for instruction and assessment in introductory statistics. *None* of the items had a truly social context. A large majority of the GAISE 2016 item were *completely decontextualized* and did not cover the rich and diverse types of texts and visualizations that are the hallmark of how civic statistics are communicated to the general public. The upshot is that there is an urgent need for fresh thinking if we want to see more attention to civic statistics with better examples for activities, and teaching principles that can help students engage with civic statistics.

16. **Looking ahead.** Part 2 below sketches the knowledge bases and other enabling processes that we believe should be acquired in order to fully engage with and critically evaluate civic statistics. Part 3 outlines the types of teaching resources and other materials that we developed at ProCivicStat. Part 4 then discusses in more detail the six recommendations outlined in the Executive summary. Finally, Part 5 presents some conclusions and reflects on possible next steps.

Part 2: A conceptual framework of knowledge and skills for civic statistics

17. Part 1 reviewed six key features of civic statistics. Here we further reflect on the knowledge bases, skills, and other enabling processes that are needed to access, comprehend, interpret, critically evaluate, and react to civic statistics. The analysis in this part aims to clarify the multi-faceted and complex nature of what students and citizens need to acquire, hence helps to understand the need for developing new teaching methods and resources focused on civic statistics.

18. As a preface, it is important to note that a very broad multi-disciplinary literature exists that can inform the creation of models describing the knowledge bases, skills, and attitudes needed to access, understand and engage with civic statistics. Here is a list of most (but not all) types of perspectives and models that we have reviewed.

1. Models related to adult numeracy, mathematical literacy, and related constructs (e.g., Kilpatrick, 2001; Gal et al., 2005; PIAAC Expert Group, 2009; Geiger, Goos & Forgasz, 2015; Tout & Gal, 2015)
2. Models related to broad quantitative reasoning (QR) competencies (e.g., Boersma et al., 2011; Madison, 2014) and to reasoning in statistics in particular (Biehler, Frischemeier, Reading & Shaugnessy, 2017).
3. Heuristics related to critical reading of quantitative statements and other aspects of critical thinking (e.g., Gal, 2002; Ridgway, Arnold, Moy, & Ridgway, 2016)
4. Models related to statistical literacy, probability literacy, and official statistics literacy (Gal, 2002; Watson, 2002; Gal, 2004; Gal & Ograjenšek, 2017; UNECE, 2012).

5. Models describing cognitive processes in understanding tables and graphs (e.g., Friel, Curcio and Bright, 2001; Shaughnessy, 2007; Kemp and Kisanne, 2010; Sharma, 2015; Prodromou, 2015)
6. Models and perspectives describing desired outcomes of statistics education or needed extensions in the 21st century digital world (e.g., Wild, & Pfannkuch, 1999; Ben-Zvi & Garfield, 2004; GAISE 2016; Ridgway, 2016; Gould, 2017)
7. Models related to dispositions, attitudes and beliefs that can support numerate behavior and statistical literacy behavior (e.g., Kilpatrick, 2001; Gal, 2002).
8. Models related to skills and knowledge required for civic literacy, citizenship education, citizen empowerment, and related fields (e.g., McGregor, 2005).

19. The relevant perspectives and models, such as those listed above, are of two general "families". Some are relatively broad and reflect generic expectations regarding general outcome of schooling (e.g., expectations of quantitative reasoning programs, aspects of critical thinking), while others are more specific to the area of statistics and probability. All of these reflect separate conceptual developments over the last few decades, but they have not all been integrated under one roof. Of course, there is some overlap between the models, but each offers additional terminologies and ideas that may be useful for future work related to civic statistics.

20. Based on a review of relevant literature related to the eight domains outlined above, and on an analysis of the demands of dozens of examples for civic statistics taken from various sources in several countries, we developed the model depicted in Figure 3. The model argues that the ability to engage with civic statistics involves 11 separate but related facets, organized in three groups or dimensions:

- **Engagement & Action:** Meaning for society and policy; Critical evaluation and reflection; and Dispositions
- **Knowledge:** Statistics and risk; Representations, patterns and models; Methodology and enquiry processes; Extensions in official statistics; and Contextual civic knowledge
- **Enabling Processes:** ICT and search; Quantitative core; and Literacy and Communication

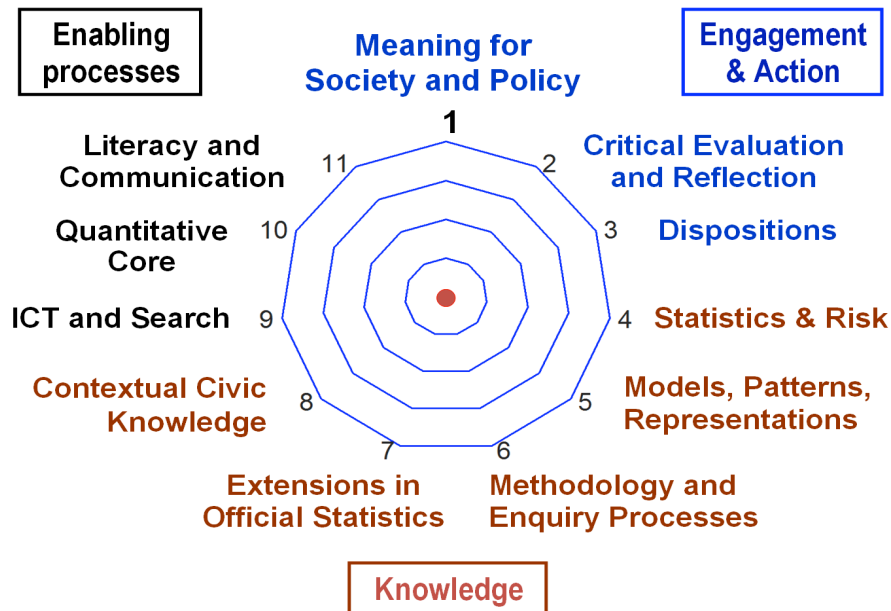
21. See Annex A for a brief description of the topics subsumed under each of the 11 facets¹. We highlight here the importance of Facet 1, "Meaning for social policy", which is the rationale and the "heart and soul" of the model of civic statistics depicted in Figure 3. Statistics about social issues are collected *because* of Facet 1 (i.e., we need data, due to societal needs for information about its status, trends, or changes), *and all other facets in the model serve Facet 1*, e.g., assist or enable us to access or collect, read and analyze, visualize and understand, and critically interpret the meaning or implications of the statistics or of data-based evidence for society and policy.

Beyond Facet 1, the "Engagement & Action" dimension includes two other key facets, i.e., critical evaluation and reflection (Facet 2) and dispositions (Facet 3). These highlight the need for a rational and reasoned approach to any data-related issue, and

¹ A more elaborate paper with in-depth scholarly discussion of the facets is under development (Gal, Ridgway & Nicholson, in preparation)

the need for citizens to be willing and motivated to engage data-based arguments – without which civic statistics degenerates to just another curriculum topic defined by (new) content and (new) processes.

Figure 3: A conceptual framework – 11 facets of civic statistics



22. The conceptual model depicted in Figure 3 describes knowledge bases, skills and enabling processes that enable understanding of civic statistics and engagement in the context of the social issues they refer to. Hence, we position this model as the foundation for and a new contribution to curriculum and task design in statistics education. Among other things, we argue that educational resources and class activities should be designed with Facet 1 in mind. To qualify as "good" or high-quality, a task or class activity needs to have a direct and clear connection with an actual societal issue. This point is reiterated here because as mentioned earlier, such contextual links with societal content and civic issues are lacking from almost all of the GAISE (2016) recommendations, despite its focus on foundations that can also promote statistical literacy (Schield, 2016). This gap sets the stage for Part 3 below, which examines educational issues related to civic statistics.

We highlight the importance of Facet 1, "Meaning for social policy", which is the focal point of the model of civic statistics, provides its rationale, and motivates all other facets in the model.

Part 3:

Building blocks for teaching and promoting civic statistics

23. This part discusses the elements needed to develop and promote the knowledge and skills associated with civic statistics, which have been sketched in Figure 3 and briefly described in Annex A. As argued earlier, many of the issues listed in Figure 1 are ignored or pushed aside in the design of regular curricula and teaching programs in statistics (though some receive increased attention in courses or programs falling under "Quantitative reasoning" or "numeracy" in some USA universities and colleges - see, e.g., Madison, 2014).

24. The PCS partners have developed an integrated framework depicted in Figure 4, summarizing the key building blocks or elements that in our view need to be in place in order to enable a systemic change and growth in teaching focused on civic statistics. The elements listed in Figure 4 are organized in four layers or levels, from broad publications for encouraging public discourse and awareness, to general guidelines, specific teaching resources (instructions and lesson plans or activity sheets for teachers and for students regarding datasets, visualization and analysis tools, selected media articles and texts from official statistics producers, and more), and finally various supporting materials and other auxiliary products which are hosted on the PCS website.

Figure 4: A visual overview of ProCivicStat outputs and desired elements

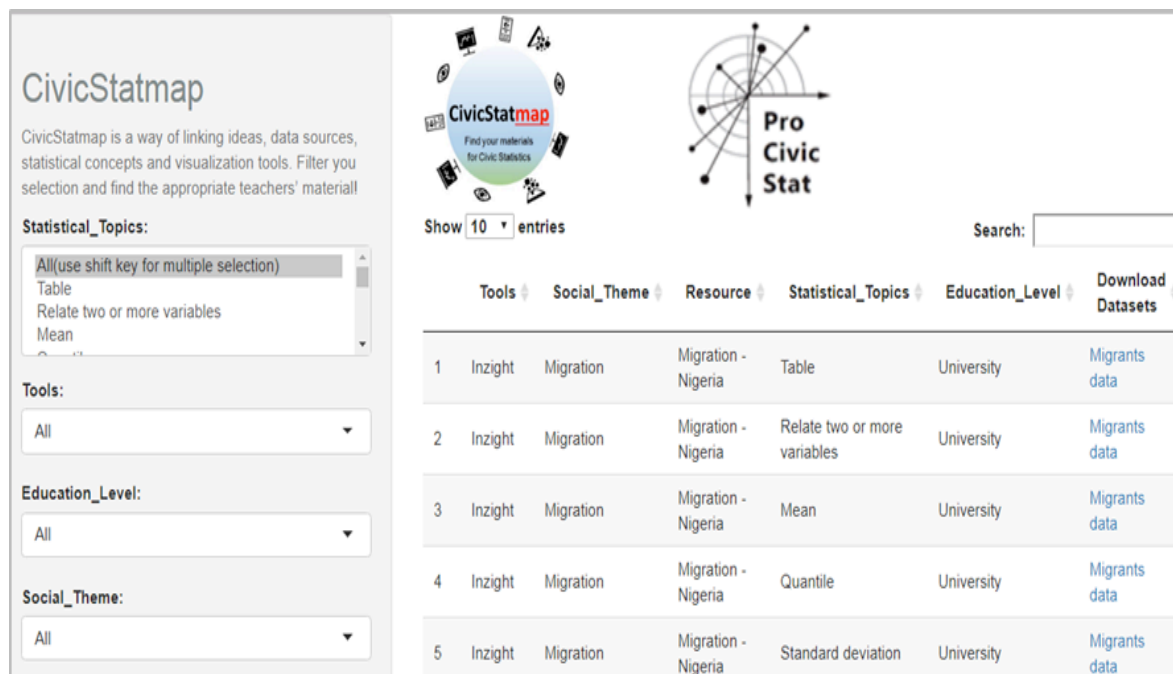
Public discourse	Call for Action & Recommendations		A Book about PCS and Civic Statistics	
Broad Frameworks	Conceptual Framework of needed skills (Short, Long)	Guidelines for task design & assessment (with examples)		Course designs - for all students - for pre-service
Instructional Resources	CivicStatMap (task design tool)	Lesson plans	Dataset guides	Workshop and visualization guides
	For Teachers		For Students	
Supporting materials	Conference proceedings	Papers by PCS partners	PCS website (at IASE)	Bibliography, links, etc

25. The authors of course do not claim that PCS is the only project creating materials related to the promotion of statistical literacy or to the understanding of statistics about society. Many relevant resources are catalogued on www.statlit.org, a website

developed and maintained by Milo Schield at Augsburg College, USA. Many resources are listed in publications and books by Jane Watson (e.g., Watson, 2013), in Ben Zvi and Garfield (2004), and many others.

However, Figure 4 aims to go beyond mere lists of resources. Figure 4 conveys a powerful idea: since statistics requires a different focus than traditional teaching of statistics, to promote civic statistics we need *an integrated set of resources and instructional sequences that are coordinated with an overarching conceptual framework* of the knowledge bases and skills associated with civic statistics. Thus, lesson plans or class activities that purport to address some aspect of civic statistics need to be designed in such a way that it is clear to what facets of the ProCivicStat conceptual framework they are linked or aim to enhance. Similarly, datasets and data-analysis activities need to be designed with direct and clear connection to a societal issue and embedded in a social-relevant context, and so forth.

Figure 5: CivicStatMap main screen



	Tools	Social_Theme	Resource	Statistical_Topics	Education_Level	Download Datasets
1	Inzight	Migration	Migration - Nigeria	Table	University	Migrants data
2	Inzight	Migration	Migration - Nigeria	Relate two or more variables	University	Migrants data
3	Inzight	Migration	Migration - Nigeria	Mean	University	Migrants data
4	Inzight	Migration	Migration - Nigeria	Quantile	University	Migrants data
5	Inzight	Migration	Migration - Nigeria	Standard deviation	University	Migrants data

26. CivicStatMap—a tool for discovery of teaching resources on civic statistics. To help educators coordinate key building blocks when planning instruction on civic statistics, PCS has designed a new tool, called CivicStatMap, depicted in Figure 5 (see a prototype here: <https://rstudio.up.pt/shiny/users/pcs/civicstatmap/>). This tool is based on an R-Shiny application developed in RStudio. The objective of CivicStatMap is to provide teachers and students with a way to access teaching materials quickly, by choosing appropriate filters such as *Language*, *Education Level*, *Social Theme* (e.g., crime, pollution, migration, equality, etc), and the *Tools* they will use (e.g. iNZight, JMP, R, Tableau). It also shows-the statistical ideas learners may encounter.

27. Regarding social themes, CivicStatMap links to teaching materials on topics such as income inequality, natural disasters, refugees, poverty, migration, alcohol consumption, malnutrition, adult numeracy (based on PIAAC data), and mathematical

literacy (based on PISA data), among others. Underlying CivicStatMap is a database containing the different teaching materials and the different features (datasets, visualization tools, social themes and statistical topics) as attributes. Datasets for these and other lesson plans were obtained from various statistics providers, such as Center for Research on Disaster Epidemiology (CRED), the Armed Conflict Site and Event Data Project (ACLED), the Center for Disease Control and Prevention (CDC), the Institute for Women's Policies Research, OECD, UN, UNICEF, the World Bank, the World Health Organization (WHO), and many others.

28. The types of products and resources sketched in Figure 4, together with the functionalities in the interactive CivicStatMap, offer a tentative roadmap for resource development in the future. In some of the cells, the PCS partners have been able to make substantial progress and create many resources. In others, we have ideas and some preliminary products, but much is left to be done, in terms of developing new materials, as well as in terms of linking existing resources and materials that are spread around the world into the CivicStatMap, so teachers in schools, university lecturers, and various trainers and teacher educators can take action and adopt some of the recommendations and ideas that emerged from the ProCivicStat project and subsequent discussions.

Part 4: Key recommendations explained

29. **Overview.** This section elaborates on the six key recommendations listed in Table 1 in the Executive summary. Note that these recommendations are a *system* and should not be viewed in isolation: Recommendation 1 is about the heart and soul of civic statistics: the focus on social phenomena and social policy. Recommendations 2-5 examine subareas related to implementation issues: information resources for teachers (i.e., datasets, articles and press releases), curricula, technology, pedagogy, assessment, etc. Recommendation 6 examines more broadly the factors and stakeholders related to a systemic change, beyond the focus on class-based teaching-learning processes. These systemic issues are further discussed in Part 5 which closes this report.

We emphasize that the recommendations listed below are *not* etched in stone but should be viewed as an evolving set of ideas which are open to commentary and further development, beyond what was possible in the three years during which ProCivicStat operated. Our ultimate aim is to promote dialogue among stakeholders involved in statistics education and statistical literacy, broadly viewed². We thus invite further reactions and call on the statistics education community to be further involved.

² Draft versions of some recommendations were discussed at the ProCivicStat closing Roundtable "Civic Statistics and Citizen Engagement: A Call for Action," which was held at the Max Planck Institute for Human Development, Berlin, August 27-28, 2018. The ProCivicStat partners have invited colleagues from diverse countries and stakeholder groups (see Annex E for list of participants) to discuss issues involved in the promotion of understanding of civic statistics, and provide critical commentary regarding future actions and needed changes. The recommendations listed in this report are based in part on discussions at this roundtable (as well as on prior work by ProCivicStat partners), but should not be viewed as endorsed by all participants in any of the ProCivicStat events.

30. Recommendation 1: Statistics education activities should promote engagement with social issues and develop learners' critical understanding of statistics about key civic phenomena.

Statistics as a discipline is valuable because it can empower people to address real-world problems, and enable engagement with complex social phenomena. Statistical techniques are tools to use, not badges to be acquired. Curricula should be examined to explore the extent to which they empower and engage learners in addressing issues of relevance to society. The ProCivicStat project has produced a conceptual model (see Figure 3) and a conceptual framework (see Annex A) to support these activities. A tool for analysing tasks and activities (see Annex C) is available to support curriculum planning in evaluating the extent to which the range of relevant skills and dispositions are covered by a proposed set of activities.

R1: Activities should:

- have a clear rationale for content and learner activities, based on some conceptual framework that reflects a broad range of statistical skills, especially those relevant to social issues
- The rationale should be made clear to students via a clear conceptual framework, illustrated by tasks and activities that illustrate mastery of the elements of the conceptual framework
- promote an understanding of the role of evidence in public decision making – notably concepts of uncertainty, risk and utility, and the inter-relations between them.

31. Recommendation 2: Use relevant data and texts, and highlight the multivariate, dynamic and aggregated nature of social phenomena

Understanding social phenomena, and thinking through the implications of possible policy decisions in the social arena requires an understanding of, and ability to work with multivariate data. Many courses make exclusive use of artificial data - this does students no favours! Students need to be aware of major data sources, the quality and the comparability of data, know how to access and manage large data files, and know how to work with, and reason about, multivariate data.

R2: activities with data should:

- include content on major societal issues for humanity (for example; climate change, inequality, and migration)
- access and use data from major data providers (e.g. Eurostat, UN, and OECD) and include both aggregated and disaggregated data
- use multiple sources of data, especially new sources of data (including big data and social media) to triangulate problems – and be aware of measurement issues.

32. Recommendation 3: Embrace technologies that enable rich visualizations and interactions with data about relevant social phenomena

‘Statistics’ will disappear as a discipline if it stays within the confines of well-ordered data submitted to standard packages. Graduates will not have skills needed for

employment; graduates will not be equipped with skills in handling novelty nor be empowered to answer challenges of our ever-changing world.

R3: Activities should:

- embrace relevant current and emerging technologies. These include:
 - using dynamic and interactive data visualisations
 - teaching students to learn to evaluate and use unfamiliar tools - including tools from data science (e.g. CODAP)
 - requiring students to use a variety of tools to conduct access and analyse data, and to present their analyses and conclusions.

33. Recommendation 4: Teaching methods should develop skills of critical interpretation of a wide variety of data and text sources.

Activities in Civic Statistics are rather different from standard courses in statistics, research methods or social statistics, and aim to develop skills in statistical reasoning.

R4: Activities should:

- employ a variety of teaching strategies, with an emphasis on active learning approaches where learners formalise questions, find evidence and choose appropriate methods of analysis
- develop skills of critical interpretation via analyses of a wide variety of sources (including newspaper articles and ‘fake news’)
- encourage students and pupils to communicate about social issues by creating narrative accounts of complex situations, based on multiple sources of statistical evidence
- introduce reasoning with non-linear, and with multivariate data relevant to important social issues, early in the course
- develop modelling skills so that learners bring an awareness of the strengths and weaknesses of tools used to model social situations
- engage pupils and students with the variety of ways that evidence is used to support theory in different academic disciplines.

34. Recommendation 5: Assessments should examine the ability to investigate and critically understand data, statistical findings and messages about key social phenomena.

The assessments that learners face during and at the end of any course are the strongest guide for learners about what is to be learned, and the extent to which they are making progress.

R5: Activities should:

- embody (formative and summative) assessment systems that reflect the designers’ ambitions for student outcomes relevant to Civic Statistics – in particular, the ability to relate data analyses to *meaning for society and policy* should be assessed
- be consistent with assessment systems that allow learners to display mastery of the skills advocated under R4 using the content matter and tools advocated under

R3 e.g. via project work or portfolios, using videos, presentations or other non-traditional media, either as individuals or in groups.

35. Recommendation 6: Promoting the understanding of civic statistics requires a systemic change and collaboration by relevant stakeholders.

Civic Statistics needs institutional support if it is to become a practical reality for everyone. This requires a coherent plan for systemic change. In some contexts this could begin by infusing Civic Statistics lessons into otherwise traditional courses. In other contexts, it might be appropriate simply to use authentic large-scale data sets relevant to social problems to teach traditional topics. In other contexts it may be necessary to engage in radical curriculum reform.

R6: Educational institutions (i.e., schools, colleges and other tertiary providers) should:

- review individual courses and programmes of study to assess the extent to which Civic Statistics is addressed
- ensure that Civic Statistics is a major element in pre-service and in-service courses, and that teachers experience the challenges of drawing conclusions about policy from complex data sets
- encourage teachers and faculty to engage with, and provide opportunities for engagement in, scholarship related to Civic Statistics
- encourage collaboration between teachers in related disciplines
- encourage cooperation with official statistics providers and the media.

36. Looking ahead. Part 5 below discusses further aspects and implications related to systemic changes that are needed to promote understanding of civic statistics. It elaborates on issues related to high-schools and middle schools, and to the role of official statistics providers, the media, and other stakeholders, and further steps related to needed research and capacity-building.

Part 5: Conclusions and further implications

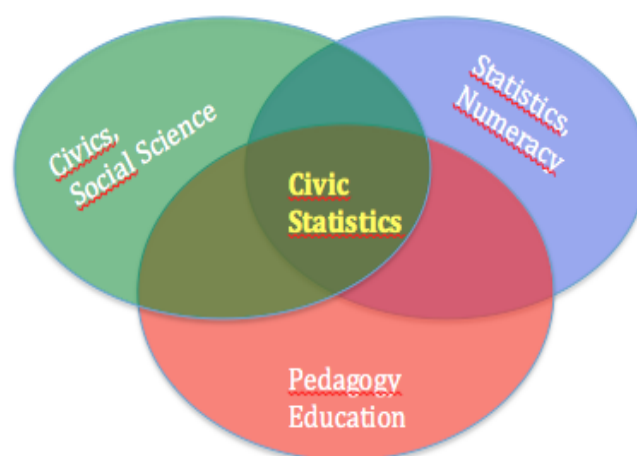
37. This report argues for the need to rethink the educational approach used to teach statistics. We argue that in modern democracies, effective citizen engagement with social issues requires active participation, and that this in turn requires, among other things, a broad range of skills relevant to understanding data and statistics about social issues. Statistics nowadays is part of the school curriculum in most countries. Yet statistics education both in high school and colleges is lagging behind the demands for informed citizenship. Many statistics classes and educational resources, either at the high-school or university/tertiary levels, or many of the resources targeted at adults and citizens at large, are not designed to teach skills and understanding that are directly related to the characteristics of civic statistics, despite the importance of civic statistics and the fact that public access to evidence and statistical findings that can inform social decision-making has never been better or more open.

38. The content of introductory statistics courses, and related teaching approaches have been the subject of scholarly analysis over several decades. Numerous scholars have debated the sequencing as well as relative importance and weight of some components (Moore and Cobb, 2000; Chance and Rossman, 2001; Cobb, 2007; Malone et al., 2012; Ograjenšek and Gal, 2016), or called for improving conceptual understanding of big ideas in statistics and putting less emphasis on computations and procedural knowledge. Further, the recent college-level GAISE 2016 Guidelines, which are receiving attention all over the world, emphasize the need to use "real data in the classroom".

39. However, in our view, even such changes fall short from involving students with data and findings about *socially meaningful issues of concern to citizens and policy makers*. Teaching traditional statistical content in a better way does not ensure that students are familiar with the unique characteristics of civic statistics discussed in Part 2, or that they acquire the full scope of knowledge-bases and skills described in part 3. Familiarity and actual experiences with all of these are needed to engage with or critically interpret the many types of data-based messages, media articles, and professional reports that refer to findings and trends on burning issues in society, or to be able to aware of and combat "fake news" that are more common today, and understand notions of evidence-based decision making.

40. Civic statistics as portrayed in this report should not be seen as a subset or a "simple" version of the regular statistical content encountered in introductory statistics classes. Given the six unique features of civic statistics reviewed earlier, and the many knowledge bases, skills, and supporting attitudes and enabling processes depicted in Part 2, we argue that civic statistics is in fact a broader area that presents new challenges to those involved in statistics education or who want to promote citizen engagement with data about society and with burning social issues.

Figure 6: A multidisciplinary view on civic statistics



41. **Laying foundations - the high-school level and middle-school levels are a key.** We already touched in paragraph #5 on the educational gaps at the high-school and college levels. We wish to focus further on the *high-school* and *middle school* levels.

Given that only a portion (in many countries only a minority) of high-school students will continue to tertiary education, the *foundation* in civic statistics for all future citizens should be provided at the school level, where in the higher grades students can certainly understand the connection between statistics and wider societal issues. However, few high- and middle- school teachers in mathematics (or in science and social science) receive any solid training in statistics or in the pedagogy of how to teach statistics (Callingham & Watson, 2017).

As a result, teachers might tend to stay within their comfort zone and overemphasize a narrow range of statistical techniques and computations (mathematics), and might fail to engage with deeper statistical ideas or with working with and understanding multivariate data that describe social trends, or to the analysis, interpretation and communication about the meaning of such data. Most current statistics curricula at the school level focus on simple issues and employ single- (or perhaps two-) variable problems, and promote technical mastery of techniques developed over 100 years ago; they often use artificial data unrelated to societal contexts, and they make little use of modern data visualization techniques that are able to show dynamic trends and changes over time in important social phenomena.

42. School systems and school-level educators face the challenge to teach a different mix of quantitative and statistical skills from those in current curricula, using unfamiliar data sets, if students are to understand and interpret civic statistics. Statistical techniques taught and data sets used in current curricula (at the high-school and introductory university levels) are misaligned with the needs of engaged citizenship as envisioned above. Attention in mathematics and statistics classes focuses too much on mastery of traditional technique (e.g., regression formulas, analysis of variance) and mathematical underpinnings, and on simple datasets, rather than on the skills required for understanding patterns and changes in socially meaningful phenomena, such as complex graphs and aggregate tables, and discussing underlying causal factors. There is little attention to statistical thinking, and no exemplification of the power of statistics as an aid to understanding social (or other) phenomena (Ridgway, 2015).

The subfield of civic statistics sits at the crossroads of multiple disciplines, as depicted in Figure 6. Hence, a multidisciplinary educational perspective is needed, stepping outside the comfort zone of traditional statistics education.

43. **Dissemination, outreach, and expansion of resources.** The issues above require fresh thinking about dissemination and outreach approaches related to civic statistics. Poster competitions focused on statistical literacy and on the use of official statistics data (MacFeely, Campos, and Helenius, 2017) and other activities such as those of the International Statistical Literacy project are one of the basic steps that can be taken in this

regard. However, there is a need to go much beyond that in order to promote civic statistics. ProCivicStat started to promote dissemination and outreach activities in newsletters geared toward practitioners in different countries (e.g., Kovacs, 2018) and through the organization of dedicated conferences and sessions on civic statistics in several international conferences. In addition, PCS has created on the PCS website a collection of teaching/learning resources focused on civic statistics. As of Fall 2018 this collection will be permanently hosted by the International Association for Statistical Education (IASE) as part of the resources of the International Statistical Literacy Project (ISLP) here: <http://iase-web.org/islp/pcs>. However, there is a need to examine how this collection can be made into a centralized warehouse and what updating mechanisms can be put in place, and by whom, in order to ensure it can be kept up to date and enriched on the basis of new contributions well beyond the nucleus provided by PCS itself.

44. Official statistics producers and other stakeholders. We also argue that there is a need for new or re-energized types of public education and for new training tools and efforts by statistics providers, irrespective of any changes that may be introduced at the tertiary or high-school levels. This is because many types of civic statistics are created and reported by official statistics agencies and other providers who make them open to the public or at least publish press releases and various types of technical reports or visualizations. Some types of civic statistics are now emerging via tools for (relatively) open access to sources of big data, to datasets from public and private providers, from multilateral collaborations and from media initiatives and "data journalism".

Regardless of their source, providers of statistics on civic issues, both official and others, are usually interested in making sure that their products not only are available and accessible, but that the public trusts them and uses them in diverse ways. However, the characteristics of civic statistics (multivariate, dynamic, aggregated, using rich texts and rich visualizations) set them apart from many of the statistics and data types included in traditional instruction in statistics.

45. We note that effective understanding of reports, press releases from official and open sources or of media articles, or using new types of visualization tools that are made available to the public, often requires different skills and knowledge than the more traditional content included in existing statistics teaching (UNECE, 2012; Gal & Ograjenšek, 2017). Examples for key skills involve a critical appreciation of data provenance and quality, of metadata information, and an understanding of statistical ideas associated with analyzing large multivariate datasets. Inferential techniques such as hypothesis testing may be less relevant when analyzing very large data sets. Instead, important ingredients of multivariate thinking imply the search for interactions, awareness of confounders, understanding pros and cons of aggregation or disaggregation of data (e.g., Simpson's Paradox); benefits and costs of observational studies and surveys vs. (controlled) experiments, etc. Important mathematical methods, supported by technology-based visualization tools, include discovering and modeling functional relationships between two or more variables, including exploring nonlinear relationships, exploratory smoothing techniques, and more.

46. Summary: We argue that the gaps and needs discussed in this Call, as well as the characteristics of civic statistics and the complex set of knowledge bases, skills and enabling processes that are needed to engage them, present important needs and

opportunities, as well as many barriers and challenges, to all stakeholders. For this reason, this report calls for the promotion of a new educational subfield we call civic statistics, which focuses on understanding quantitative messages and statistical information about society which is provided by the media, statistics offices and other statistics providers. We present *Recommendations for Action* designed to stimulate curriculum innovation in high schools and universities.

Annex A:

Elaboration of the 11 facets of the civic statistics model

Purpose: This Annex provides further information about the scholarly and theoretical foundations of the model of knowledge bases, skills, and enabling processes for civic statistics. Further, it provides brief explanations about the 11 facets included in the Conceptual Framework depicted in Figure 3.

Sources: This annex is a slightly modified version of a paper presented at ICOTS10, by Rosie Ridgway, Iddo Gal, and James Nicholson, in collaboration with Jim Ridgway (See citation in Annex B, for: Ridgway, Gal & Nicholson, 2018). The paper uses texts from ProCivicStat workshops (e.g., Ridgway, Nicholson, and Gal, 2017).

Introduction

There is a widespread belief that citizens should be able to make wise decisions, participate effectively in societal processes, and promote their own well-being (OECD, 2012). Geiger *et al* (2015) emphasize the importance of numeracy skills as part of 21st century demands. Friel *et al* (2001), in their discussion of the cognitive processes involved in understanding tables and graphs, also discuss the importance of knowledge about context. They describe *reading behind the data* (i.e. understanding context, and drawing on knowledge about the situation and the factors or processes that influenced data collection), as well as *reading the data*, *reading between the data*, and *reading beyond the data*.

Thus, citizens need statistical literacy and probability literacy in order to be able to evaluate the quality of the evidence offered – this includes the way it was gathered (e.g. via a randomized controlled trial, or via epidemiology) and analyzed. Gal (2005; 2009) defines Probability Literacy as “*The ability to access, use, interpret, and communicate probability-related information and ideas, in order to engage and effectively manage the demands of real-world roles and tasks involving uncertainty and risk.*” Gal (in review) also argues that citizens increasingly encounter expert predictions about probability and risk in contexts such as elections, global warming, and health (e.g. the probability of getting breast cancer). These predictions are based on quite different sorts of data and modelling assumptions compared to traditional notions of probability and risk.

Despite these grand ambitions for citizen literacy, results from large-scale surveys of adult competence in reasoning about numerical evidence in real-world settings make rather dismal reading. An OECD survey of financial literacy of adults in 16 countries (Atkinson & Messy, 2012) found that fewer than half of the adults surveyed understood the reasons for diversifying one’s investments; a study by the US National Science Foundation (NSF, 2014) based on repeated surveys of national samples of adults revealed that less than 40% of respondents understand that an experiment involves a control group; von Roten *et al.* (2013) provide vivid examples of knowledge deficits in science literacy and statistics. These results, in part, can be attributed to a lack of attention in education systems to the application of statistical ideas to real-world issues; it is interesting to note how little emphasis is placed on real-world applications of probability in national curriculum documents such as those from Australia (www.australiancurriculum.edu.au), or the USA (www.corestandards.org/Math).

Here, we build on earlier work and map out some important dimensions of statistical literacy (SL); we acknowledge that the concept is dynamic, and likely to change in the face of major cultural upheavals associated with data science. Frameworks associated

with Adult Numeracy provide starting points for conceptualizing SL. The model of adult numeracy in the OECD Survey of Adult Skills (PIAAC Expert Group, 2009) refers to three key categories: *responses* (e.g. locate, compute, evaluate, communicate); *mathematical information and ideas* (e.g. data and chance, pattern, relationships and change), and *representations* (e.g. technology-based displays, texts, graphs and tables) (Tout & Gal (2015) discuss links between the conceptual frameworks for Adult Numeracy in PIAAC and Mathematical Literacy in PISA). Gal (2002) distinguishes between *knowledge elements* (such as statistics and probability, and contextual knowledge), and *enabling processes* (such as information search, and evaluation skills).

Boersma *et al.* (2011) and Madison (2014) describe six core competencies that are required for responses to tasks that call upon quantitative reasoning: *interpretation* (the ability to glean and explain mathematical information presented in a variety of forms); *representation* (the ability to convert information from one mathematical form to another); *calculation*; *analysis/synthesis*; *assumptions* (the ability to make and evaluate assumptions in estimation, modeling, and data analysis); and *communication*. Literacy (in the sense of competent use of language) is an important component of SL because quantitative information is often embedded in text. Kilpatrick *et al.* (2001) and Kilpatrick (2001), describe *strategic competence* (ability to formulate, represent, and solve mathematical problems) and *adaptive reasoning* (capacity for logical thought, reflection, explanation, and justification) in their discussions of mathematical proficiency and mathematical literacy.

Statistical literacy is not simply about mastery of technique; it involves habits of mind – a willingness to engage with data – and enabling processes – the ability to reason with numerical evidence. Below, we describe facets of statistical literacy that underpin the ability to engage with social issues – i.e. Civic Statistics. The core facet is Meaning for social policy; every other aspect of statistical literacy contributes to this facet. We identify three groups or dimensions of (non-orthogonal) facets. These are elaborated, below, and exemplified via questions.

- **Engagement & Action**, comprising: Meaning for society and policy; Critical evaluation and reflection; and Dispositions
- **Knowledge, comprising:** Statistics and risk; Representations, patterns and models; Methodology and enquiry processes; Extensions in official statistics; and Contextual civic knowledge
- **Enabling Processes, comprising:** ICT and search; Quantitative core; and Literacy and communication

Dimension 1: Engagement & Action

Facet 1: Meaning for social policy

This facet is at the heart of statistical literacy – students and citizens need to be able to form a view of what could and should be done to address some policy issue, grounded in evidence. In practical settings, decision making is associated with weighing existing evidence, and also with notions of risk – probabilities, costs and benefits, expected values, and subjective utilities. There is a need to address not only the immediate impact of any proposed policy change, but also the knock-on effects of any course of action. So an analysis of likely social impact is needed to complement statistical analysis and any recommendations.

In many European countries the population is increasingly dominated by old people. What are the implications for pensions and health care? What actions might be taken, and what ‘unintended consequences’ need to be considered?

Facet 2: Critical evaluation & reflection

‘Post-truth’ and ‘alternative facts’ are attacks on the heartland of informed decision making. Even when using data from well-authenticated sources, there is still a need for critical evaluation and reflection. Critical evaluation and reflection should be habits of mind – questions one triggers routinely without much conscious effort. For example:

- What is the story being told – whose story, and why are they telling it?
- Has the problem been identified appropriately?
- What evidence is being presented? From a credible source?
- Have appropriate statistical models been chosen (e.g. is it OK to assume data are normally distributed? Has linearity been assumed?)?
- What else could be going on – a confounding variable?
- Are the conclusions consistent with the evidence?

A study shows that recent migrants are below average intelligence.
Identify 3 distinct factors that might invalidate the conclusions from this study.

Facet 3: Dispositions

Great skills with statistics are unlikely to be useful in everyday life unless they are associated with positive dispositions. Dispositions are emotional responses associated with a willingness to engage in evidence-based argument. Negative dispositions are exemplified by statements such as ‘lies, damn lies and statistics’. Positive dispositions are exemplified by the actions of fact checking organisations such as *Full Fact* and *Chequeado* who offer non-partisan commentaries on statements by politicians and in the media.

Dispositions reflect a complex web of motivations, beliefs, and attitudes. They have a social dimension, such as a willingness to share interpretations with others. They have components, e.g., self-efficacy, confidence, that affect engagement in both positive and negative ways. Dispositions about one’s own state of knowledge are important. Ignoring evidence because of prior beliefs, accepting new information uncritically, or believing that social phenomena can only be understood by experts, all reflect unhealthy dispositions.

This facet is not easy to assess with written question! Indirect evidence would be persistence in exploring (say) web-based resources relevant to a contemporary issue. Healthy dispositions are exemplified by positive habits of mind and positive attitudes and beliefs – when faced with evidence and argument, it is expected that learners and adults routinely ask questions such as:

- Can I play with or analyse the data myself?
- Can I find other information to confirm or disconfirm the stories told here?
- Do I trust my own ability to pose critical questions about published statistics? Do I need to boost my own knowledge and if so how?
- Do I have the right to question or doubt statistics reported in the media?

Dimension 2: Knowledge

Facet 4: Statistics & Risk

This facet includes much of what is commonly taught in introductory statistics courses. Basic topics in statistics relevant to Civic Statistics include: samples, populations and representativeness; variability; describing and comparing distributions; association and

correlation; regression; non-linearity; signal and noise; interaction; Bayesian inference; bounded estimates; and effect size.

Understanding risk is an essential ingredient of Civic Statistics. It relies on probability and conditional probability (including Bayes' theorem), expected values, utility and subjective utility.

Civic Statistics also requires an understanding of some of the ideas around Big Data - such as familiarity with a wide variety of data sources and associated techniques of analysis, notably those used for detecting patterns.

Jim will spend a month in Paris. Put these sources of danger in order from highest to lowest.					
Terrorist incident		Traffic accident		Shark attack	
Explain your answer.					

Facet 5: Models, patterns, and representations

All models are wrong, but some are useful (Box & Draper, 1987, p424)

The heartland of statistics is the application of mathematical models to situations of interest. An essential component of Civic Statistics is understanding that when modelling complex social phenomena, qualitatively different models can be used to model the same phenomenon. For example, an economist and a sociologist might have quite different theories and methods for defining and studying "poverty" and have quite different theories of causality. Civic Statistics requires the ability to identify and understand the use of models, and to be able to challenge the fundamental assumptions made by any model.

Representation is a core skill in understanding phenomena. Civic Statistics requires familiarity with sophisticated representations including those that are dynamic and facilitate interaction. There has been a recent explosion in the use of ICT-based representations - Civic Statistics requires the ability to understand and critique novel representations.

The Normal distribution has been used to predict the occurrence of unusual events such as floods, storm severity, and stock exchange movements. Suggest a better model, or class of models.

Facet 6: Methodology & enquiry processes

Civic Statistics requires an understanding of the strengths and weaknesses of different discovery methods, and some procedural skills. Quantitative methods include: survey research (survey types, sampling methods, with attention paid to vulnerability to bias); and experiments (naturalistic, RCTs, with attention paid to threats to validity). Topics include: sampling and randomization; measurement (reliability and validity); questionnaire design; web scraping. Qualitative methods include: interview techniques; descriptive studies; text and image analysis; and use of tools for analyzing social media (e.g. Twitter, Facebook, Instagram, blogs).

An understanding of ethical issues associated with the production of data and the use of various research methods is also an essential component of Civic Statistics, such as the need to know about issues of confidentiality and protection of the identity of citizens.

You are asked to estimate the number of people in your country living in poverty. You have access to employment data (including wages), Google search data, twitter streams, and data on the number of food banks. Choose TWO sources and say how you would use them. Justify your answer.

Facet 7: Extensions in official statistics

Official statistics producers are a major source of evidence about social issues, but many of the core ideas they use receive little attention in traditional statistics courses, such as: survey design (and associated problems such as non-response or respondent bias); measurement issues (reliability and validity; metadata definitions); techniques such as moving averages, seasonal adjustment, case weighting and data smoothing; synthetic methods where data gathered by conventional survey data is combined with Big Data (e.g. data on mobile phone traffic or web search data).

In country A the number of unemployed people is published each month. In country B, a 12-month rolling rate of inflation is published each month. Identify one important feature of each measure. Justify your answer.

Facet 8: Contextual civic knowledge

Statistics is about modelling, and in order to model, one needs to have an understanding of the phenomena being modelled. Some of this can be factual knowledge – knowing that absorbing one million refugees in Germany (population about 80 million) is likely to be easier than absorbing one million refugees in Hungary (population about 10 million), other things being equal. Knowing that other things are certainly *not* equal requires deeper contextual knowledge. Contextual civic knowledge includes: factoids such as sizes of populations, size of GDP, national debt and resources; demographics; history and geography; regional- and geo- politics. A benefit of contextual civic knowledge is that one can look for alternative data analyses using knowledge of plausible covariates. At a higher level, if one is to understand (or do) anything about social injustice, one needs to understand communication channels and governance.

In *your* country what is the current GDP, deficit, and national debt?

Dimension 4: Enabling Processes

Facet 9: ICT & search

Initiatives such as data.gov in the USA and data.gov.uk in the UK aim to support the democratic process by giving citizens access to data that can stimulate debate and inform policy making. Many major data providers (such as national statistics offices, Eurostat and OECD) make data publicly available – however, accessing and working directly with such data sets often requires considerable technical expertise. Big Data is another important source of information for Civic Statistics. Examples include data from wearable devices, transactional data from mobile phones, and data scraped from web pages. Civic Statistics requires an understanding of the analytic techniques suited to accessing and analysing high-volume unstructured data.

ICT skills are required to engage with ICT-based tools such as statistics packages. For Civic Statistics, students must use interactive displays effectively.

What is ‘webscraping’? Give an example of how it might be used to identify a social trend of your choice.

Facet 10: Quantitative core

Quantitative skills underpin all aspects of statistical literacy. Components include number sense, ratio, percentages, rates and fractions. Number sense is about having a feel

for numbers. In Civic Statistics, very large numbers are common, and seemingly large resources may actually be small, in context. It is easy to find examples where an author has deliberately chosen to report (accurately) data that are misleading – for example, reporting a percentage increase, where the absolute number of the starting value is very small.

In country A, the number of deaths from alligator attacks rose 300% in a six-month period. A politician calls for ‘gator nets’ to be erected around all swamplands. Explain why the data should be treated with caution.

Facet 11: Literacy and communication

A great deal of information is presented as text and image in print. Text is often very dense, and being able to read fluently and absorb the overall sense of an article is an essential skill. However, both literacy and communication are moving targets. New forms of communication are emerging, that include social media, new ways to visualize data, and video. Citizens need to be able to learn how to understand and deconstruct messages conveyed in these new communication forms. For engagement in Civic Statistics, citizens also need to be able to communicate in new ways.

(newspaper header:) “*The rate of change of immigration is slowing*”

Suppose the number of immigrants is decreasing. Draw a graph or graphs and write an explanation in words, to explain the sentence in quotation marks.

Ridgway et al. (2017) show how these dimensions can be displayed as a radar plot that can then be used to analyse tasks, curricula, and assessment systems. The ProCivicStat project is creating resources to help students develop appropriate skills in statistical literacy.

Summary

Here, we have presented the whole framework, in order to provide an overview. Details of each facet are necessarily sketchy; they will be amplified and exemplified in later documents. The framework has two distinct uses. One is to provoke discussion about the needs of statistically literate citizens. We have build on earlier descriptions of statistical literacy, and have introduced new elements. However, we are aware that the framework will need to be revised in the light of emerging developments in technology, such as new forms of data visualization, new ways to access tools, and new methods of analysis that will become commonplace (such as those associated with predictive policing, or automated decision making in a variety of fields), and new methods of accessing and communicating information. The second use is in curriculum analysis and planning.

We have developed a simple tool (see Annex C, based on Ridgway et al. 2017) presents the framework in the form of a radar plot, where each dimension appears as a radius. Individual episodes in curriculum activities, or sections in a text, or items on a test or examination can be rated on every dimension. A judgment can then be made about the overall balance of activities, texts, and tests. If a curriculum designer or teacher feels that a dimension or group of dimensions has been neglected, they can look for supplementary materials. An ambition of the PCS project is to provide some of these materials, and to link to useful resources.

Large scale surveys show that many citizens are unable to reason with numerical evidence encountered in everyday life. In part, this is a result of curricula that place too much emphasis on mathematical and statistical technique, and not enough emphasis on

understanding data from realistic contexts. If curricula are to be reformed, there needs to be a clear statement of educational goals, with appropriate exemplification, and curriculum materials to support student acquisition of these goals. An analytic framework is presented here which describes the dimensions of statistical literacy, that can be used to analyze current curricula and assessment systems, and guide future curriculum development.

Annex B

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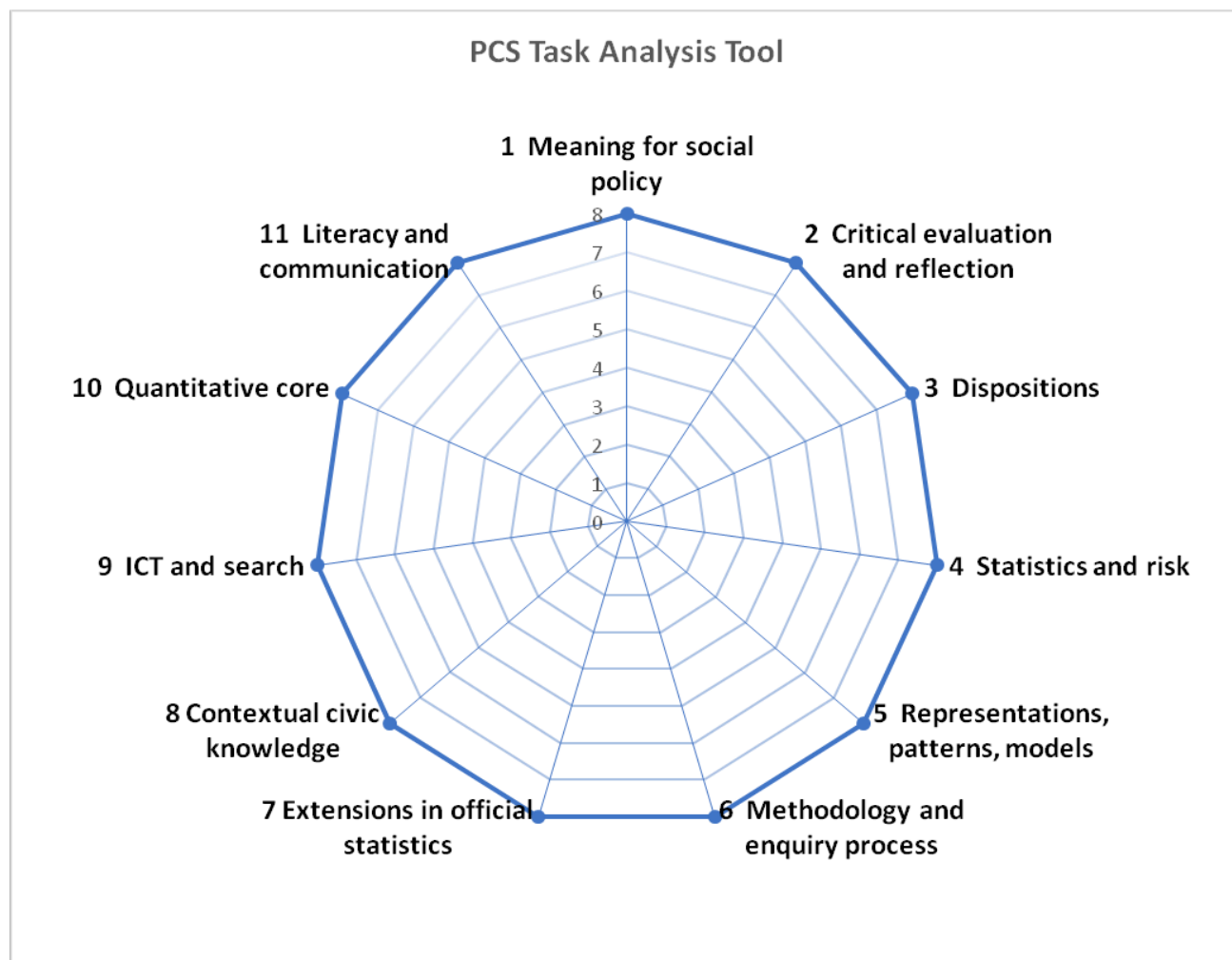
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ANNEX C

PCS Task analysis tool



Source: Ridgway, J., Nicholson, J., Gal, I. (2017). Task Analysis Tool: Facets of Statistical Literacy. Document supporting the ProCivicStat Workshop conducted at the IASE Satellite Conference, Rabat 11-13 July.

ANNEX D

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ANNEX E

List of attendees at the ProCivicStat closing Roundtable "Civic Statistics and Citizen Engagement: A Call for Action"

Max Planck Institute for Human Development, Berlin, August 27-28, 2018

Note: The ProCivicStat partners thank the colleagues from diverse countries and stakeholder groups who donated their time and efforts for fruitful discussions and critical commentary regarding issues involved in the promotion of understanding of civic statistics. The final recommendations listed in this report are based in part on discussions at this roundtable (as well as on prior work and consultations), but should not be viewed as being endorsed by all participants.

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Burrill	Gail	USA	Michigan State University
Campos	Pedro	Portugal	University of Porto and Statistics Portugal
Carter	Jackie	UK	University of Manchester
Eichler	Andreas	Germany	University of Kassel
Engel	Joachim	Germany	University of Education, Ludwigsburg
Erdmann	Elena	Germany	Die ZEIT online (newspaper)
Fleischhut	Nadine	Germany	Max Planck Institute for Human Development, Berlin
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Helenius	Reija	Finland	Statistics Finland
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Kovacs	Peter	Hungary	University of Szeged
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Krämer	Walter	Germany	University of Dortmund
Kuruczleki	Eva	Hungary	University of Szeged
Loos	Andreas	Germany	Die ZEIT online (newspaper)
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McDowell	Michelle	Australia	Max Planck Institute for Human Development, Berlin
Mittag	Joachim	Germany	Open University of Hagen

Mousavi	Shabnam	USA	John Hopkins University
Nicholson	James	UK	University of Durham
Ograjenšek	Irena	Slovenia	University of Ljubljana
Podworny	Susanne	Germany	University of Paderborn
Ponomarenko	Alexej	Russia	National Research University, Moscow
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Ridgway	Jim	UK	University of Durham
Schiller	Achim	Germany	University of Education, Ludwigsburg
Schüller	Katharina	Germany	Stat-Up Consultancy
Trzpiot	Grażyna	Poland	University of Katowice
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