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Civic Statistics in the training of pre-service mathematics teachers

In an increasingly complex world, the involvement of informed and committed citizens is a critical resource in public decision-making at international, national and local levels. The project ProCivicStat, a strategic partnership of six universities funded through the Erasmus+ program of the European Union (funding period September 2015 to August 2018), explores a subfield we call *Civic Statistics* which focuses on understanding quantitative and statistical information about society as provided by the media, statistics offices and other statistics providers (Engel et al. 2016). Understanding Civic Statistics is required for participation in democratic societies, but involves data that often are open, official, multivariate in nature, and/or dynamic, that is not normally taught in regular mathematics and statistics education, let alone in civics or social study classes. Few high school teachers in mathematics receive any training on how to teach statistics, not to speak of social science teachers who may have no training in statistics at all. As a result, teachers stay within their comfort zone and overemphasize a narrow range of statistical techniques and computations (mathematics) or fail to engage with statistical ideas at all (social science). They pay too little attention to working with and understanding multivariate data that describe social trends, and to the analysis, interpretation and communication about the meaning of such data. But capacity building for informed and committed citizens has to start in school education. While focusing on curricula at the secondary and tertiary level, the ultimate goal of ProCivicStat is to strengthen civil society, empowering informed citizens for evidence-based decision-making and civil society engagement. The challenge is multi-facetted. Data literacy for civic engagement involves, among many other aspects, specific statistical knowledge, ICT skills, knowledge about computing and data structures, critical thinking, and much more.

Concept of the seminar

In Ludwigsburg we have developed a seminar in Civic Statistics for students preparing to become secondary mathematics teachers, based on instructional design concepts following the Statistical Reasoning Learning Environment by Garfield and Ben-Zvi (2009). The focus is on the use of real and motivational datasets, classroom activities, appropriate technological tools, promote classroom discourse and alternative methods of assessment. Overarching goals are to develop critical thinking and statistical literacy in dealing with real civic data on topics like demographics, wages, discrimination,

crime, poverty etc. and to reflect the potential of using this content in the school. By working with electronic worksheets (available under www.procivicstat.org), the CQS module (see below) and video production, the seminar pursued the following goals:

- Creating and interpreting measures and graphics in civic statistics contexts.
- Understanding multivariate phenomena and their possible pitfalls.
- Critically evaluating statistical conclusions and data-based information in the media.
- Evaluating articles, datasets, and websites with civic statistical content.
- Looking at (civic) statistics content across disciplines.
- Reflecting on technology and media use.

Worksheets

Among other things, we developed various worksheets for the seminar. The worksheets do not build directly on each other, but in some worksheets statistic topics are introduced which in turn are in other condition. The worksheets also differ in three different levels of difficulty and corresponding processing time. Each worksheet deals with a topic of interest to society. The structure of the individual worksheets is similar. The students are introduced to the topic with a short description, followed by the information page with additional links to the topic, the specification of the data source, as well as a table explaining the variables of the dataset. The working part starts with the question for whom the topic could be of interest. The dataset, already inserted in the browser-based software, is available via a link on the worksheet. By means of various sub-questions, the students should be introduced by answering them to the answer to the key question. Graphic and interactive presentations as well as critical discussions with the results are particularly important. The topics of the individual worksheets used in the Seminar included: Human Development Index, Income Inequality in Europe, Happiness, Racism in Football, Overweight, and Fine dust. The worksheets can be downloaded from the homepage of the project: www.procivicstat.org.

CQS-Module

Education to *Mündigkeit* (It refers to a cluster of ideas around the goals of the enlightenment movement, cf. Schiller & Engel, 2017b) is a major goal of the educational standards of Baden-Württemberg of 2016 (www.bildungsplaene-bw.de). An important part of this is to be able to differentiate

information and opinions from each other, especially in the media. This also includes being able to assess the respective statistical facts with respect to its informative value. The CQS-Module (Critical Questioning of data-based Statements) has different key aspects (structure and content cf. Schiller, 2016; Schiller & Engel, 2017a). The module aims to show students that subjective information plays a role in disseminating information (cf. Schiller, 2016), that there are many possible different interpretations of the same information, and what information is important for evaluating data-based statements (cf. Schiller & Engel, 2016). The course of the module is modeled along the typical consumption of data-based statements in th media (cf. Schiller & Engel, 2017a and 2017b). First the students evaluate and interpret a single headline. In the second part they evaluate and interpret the appurtenant journalistic product as well as reflect their first evaluation of the headline.

Video

Producing a video about a self-chosen key question on a social topic was part of the student's exam. The task was to pose a socially relevant question, find a suitable dataset (with the support of the lecturers) and then answer this question by means of statistical analysis (mainly graphically). It was also important to describe the data set and the context as well as to critically reflect the results. Despite the high workload, the students were very engaged and motivated for the video production. As a key experience they have realized the complexity of making reliable evidence-based statements.

Summary

Civic Statistics is hardly provided, neither in the school curriculum nor in teacher training. At the beginning most students had a very mathematical conception of statistics, a poor understanding of random variability, just few experiences with data visualization tools, and little awareness of relating investigating social to statistics.The way in which students initially worked with multivariate datasets, as well as dissatisfied statements, as there were no definite results on some questions about the datasets, has shown that it is important to integrate civic statistics in the present statistical education. Nor were they aware of the possibilities and benefits of using visualization tools. The worksheets used are more or less interchangeable, they can be influenced by interests of the students. Teachng materials, lesson plans, data sets and a conceptual framework for Civic Statistics are available under www.procivicstat.org

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