

ENHANCING CIVIC STATISTICAL KNOWLEDGE OF SECONDARY PRESERVICE TEACHERS FOR MATHEMATICS

Susanne Podworny, Daniel Frischemeier and Rolf Biehler
Paderborn University
podworny@math.upb.de

Critical statistical thinking is inevitable to become a concerned citizen and to be an active part of modern society. Teachers themselves have to be well educated in several knowledge domains like content, pedagogy and technology to bring critical statistical thinking into secondary school. We have designed and realized a university course to promote civic statistical knowledge for future teachers. The focus of the course is on analyzing open data with digital tools and to develop ideas for implementing these topics in mathematics classroom. In this paper we present a best practice example and we will share our experience of the course in 16/17, the lessons learned and we will describe how we have re-designed our course for winter term 17/18.

INTRODUCTION

Enhancing civic statistics knowledge is a key concern to enable citizens to participate actively in a modern society. The definition of civic statistics and exemplary applications can be found in Ridgway (2016) and Engel (2017): Civic statistics are statistics about key phenomena in society like employment, health, education, social welfare or inequality. The project ProCivicStat (www.procivicstat.org), funded by the ERASMUS+ program of the European Commission aims at promoting civic engagement via explorations of evidence. This is a lifelong learning process that should already start in school. For implementing these key phenomena (employment, health, education, social welfare, etc.) in mathematics classroom at secondary school knowing about statistics and civic statistics is also a necessary prerequisite for teachers who have to design learning trajectories with the goal to enhance critical statistical thinking. At Paderborn University we started to educate future teachers in this important area of statistics in addition to a compulsory course on elementary statistics and probability with Fathom called “Elementary statistics”. In the preservice teachers’ master studies there is a course on enhancing civic statistics knowledge.

RESEARCH GOAL AND METHOD

Our research aim is to design a civic statistics course for preservice teachers for their master studies. So we have designed the course “Statistical literacy in mathematics classroom” in the frame of a Design-Based-Research setting (Cobb, Confrey, diSessa, Lehrer, and Schauble 2003) and have realized the first cycle in winter term 16/17, the next -second- cycle took place in winter term 17/18. In this paper we refer to the cycle of winter term 16/17, to lessons learned from this course and finally we will refer to the realization of the course in winter term 17/18.

PARTICIPANTS AND DATA

Our course in winter term 16/17 had 21 participants, in the winter term 17/18 we had 11 participants. All of the 32 participants were preservice teachers for mathematics in lower secondary school in Germany and have been at the end of their studies, having successfully attended courses on “Elementary statistics” and “Didactics of statistics”. After each session of our course we have made field notes. Furthermore we have distributed evaluation forms for the participants to rate their reflection on their understanding of the content, their interest in the content and its relevance for secondary school in each session.

DESIGN OF A COURSE ON CIVIC STATISTICS

The course consists of 15 weekly sessions, each session lasts 90 minutes. The design principles of the course are taken from the Statistical Reasoning Learning Environment from Garfield and Ben-Zvi (2008, p. 48). Fundamental statistical ideas (like data, variation, representation, etc.) are in the focus together with the use of real and motivating datasets and different technological tools for analyzing these datasets. Classroom activities and discourses are used to support students’ reasoning and formative assessment is used to monitor the development

of the participants. The main goal of the course “Statistical literacy in mathematics classroom” is to promote critical thinking towards given statistics (for example in the newspapers) and the ability to bring this thinking into classroom. On the one hand there are learning goals in regard to statistical content knowledge and on the other hand in regard to pedagogical content knowledge. With regard to the development of statistical content knowledge we intend to deepen students’ knowledge about reading and interpreting summary statistics and graphical displays (also in the sense of reading beyond data of Friel, Curcio, and Bright 2001) and to introduce students into statistical concepts and constructs (like correlation and causality or Simpson’s paradox) relevant in civic statistics. Since understanding the context is one of the most important aspects in civic statistics, we intend to introduce our participants to the operationalization of concepts like for example unemployment as another learning goal. All this culminates in the learning goal of exploring large and multivariate datasets. With regard to the development of pedagogical content knowledge we aim at ideas for implementing civic statistics in classrooms. Considering civic statistics across subjects is one of the learning goals in this respect. Another learning goal is to get to know relevant material like newspaper articles, websites, tools, and datasets which could be implemented in mathematics classrooms.

REALIZATION OF THE COURSE IN WINTERTERM 16/17

In this paragraph we will describe the realization of the several sessions in our course in winter term 16/17. The general idea was to start with an introductory task, to give a short introduction into the field of civic statistics and to confront the participants with a first activity related to civic statistics. Then students in pairs of two should lead several sessions, each dealing with one major statistical concept in a selected civic context. The major idea for these sessions was to build on the statistical content knowledge our participants have gained previously in “Elementary statistics” and to apply their statistical content knowledge in civic statistics contexts. A big project on the German gender pay gap was supposed to be the highlight of the course, followed by several small investigations in different contexts. A description of these sessions will be pointed out in the following. Sessions 1-3 were meant for introducing civic statistics. For an immediate start we used a complex statistical display on the distribution of net assets of households in Germany in the years 2003 and 2012 (for details see Biehler, Frischemeier and Podworny 2017) in sessions 1 and 2. A third session was used to refresh technological knowledge on Fathom that was known to the students in advance and should be used later for analyzing multivariate datasets. Sessions 4-9 were led by students. With meetings for preparing these sessions with the authors of this paper in advance, students were in charge of designing and moderating the sessions 4-9. There was a session about representation of data (session 4), two sessions on percentages (session 5 and session 6), a session on correlation and causation (session 7), a session on Simpson’s paradox (session 8) and one session on the concept of unemployment (session 9). Sessions 10-13 were dedicated to the gender pay gap project as a highlight of the course. Participants should use their statistical knowledge gained in previous sessions to analyze and understand a multivariate dataset from the German statistical office. The gap between income of men and women is a big discussion in German media, so our participants should look at media reports and articles and use an open dataset from the German statistical office to critically evaluate news about the gender pay gap in Germany. Concepts like unadjusted and adjusted gender pay gap should be understood and comprehended in the dataset. The unadjusted gap is about 23% that men earn more than women in Germany. For the adjusted gap there remain about 7% that cannot be explained. Depending on the purpose of a newspaper the one or the other percentage is used – sometimes without referencing to “adjusted” or “unadjusted”. The first session of the project (session 10) was about informing about the background of the German gender pay gap by reading newspaper articles and reports from the German statistical office. For the next two sessions (session 11 and 12) the participants worked in pairs on a random stratified sample downloaded from the German statistical office containing about 60,000 cases with variables like gender, wage per month, region, kind of employment, etc. Fathom was used for explorations. Participants could choose between five aspects of the German gender pay gap for their main investigation (profession, function, age, economy, or region). Another main task of session 11 and 12 was to create a presentation of the findings with the use of PowerPoint. So these sessions were not only about statistical explorations but also about how the

findings could be presented and summarized in an adequate way. All presentations took place in session 13. There were two groups for every aspect, one group was presenting and the other was an “expert” group to give feedback. In session 14 the participants worked on small projects. Five different contexts with five different tools were used, explored and analyzed for use in secondary school. Findings of the explorations in these small projects were presented in the last session. As tools we used interactive graphs or applets that can be used for free. For example one project was on unemployment, visualized by Google public data. Another dealt with sexually transmitted diseases, implemented in Smart Center Tool (see e.g., Ridgway, 2016, p. 533). Using Gapminder to explore inequalities in the world was part of another small project. For a summary, we can say that our participants have dealt with many civic statistics contexts during the course. Some were easy to understand, others had difficult context concepts (like “household”) that we did not expect to cause difficulties.

RESULTS AND LESSONS LEARNED FROM THE COURSE IN WINTER TERM 16/17

For the evaluation of the course in winter term 16/17 we collected field notes and evaluated affective and cognitive items in regard to the sessions and the tasks of the course. The overview on the evaluation can be seen in Table 1.

Table 1. Students’ rating of three statements on a scale from 1 (does not apply at all) to 7 (fully applies)

No	Topic	“I have understood today’s task very well” Mean	“I liked the content of today’s task very much” Mean	“The content of today’s task have a large didactical potential for use in classrooms” Mean
1	Introduction I	5.1	4.7	4.1
2	Introduction II	5.8	4.9	4.1
3	Exploring real data	6.1	4.9	4.6
10-	Gender Pay Gap	5.7	4.9	4.6
12	Reading and Working			
13	Gender Pay Gap Presentation	6.0	5.7	Not asked
14	Small PCS projects	5.6	5.0	4.4

As we can see most of the participants liked the activities on civic statistics very much. Especially in the project work of the Gender Pay Gap, our participants have been motivated and really engaged (for further details see Biehler, Frischemeier, and Podworny 2017). Major further findings of the analysis of these data are that participants needed to refresh their statistics knowledge (e.g., in regard to correlation and causation, in regard to describing, interpreting and comparing distributions, etc.) more than expected. One major idea in winter term 16/17 was that the students’ sessions (sessions 4-9) would help to refresh and deepen the statistical content knowledge of the participants. But in the process of the course and also with a view on the field notes, we conclude that the session leaders have been overloaded with their mission – one main finding is, that the session leaders would have needed more support in generating goals for the session, in choosing adequate activities, in using adequate statistical language and in giving adequate feedback to the other participants working on small activities. In addition, the data exploration with Fathom caused some problems, so the participants also would have needed to refresh their technological knowledge more, even though they had a whole course “Elementary statistics” with the use of Fathom some semesters ago.

RE-DESIGN FOR COURSE IN WINTER TERM 17/18

When reflecting on the lessons learned and thinking about the redesign of the course for the second cycle in winter term 17/18, we decided to keep the general structure of the course and

we decided that the refreshment of the statistical content knowledge should play an important role in this redesign. Since it was not enough to enhance the statistical knowledge in the students' sessions in winter term 16/17, we decided to implement the sessions on refreshing the relevant statistical knowledge in a more teacher-centered manner, done by the first and the second author of this paper. Furthermore we decided to implement more project sessions, since our participants worked on these activities very engaged, they liked them very much and they also saw potential for implementing these activities in their further teaching.

Table 2. Structure of redesigned course for winter term 17/18

Sessions	Content
Introduction (1)	First civic statistics activity, What is statistical literacy/civic statistics?
Refreshing statistical content knowledge (2-5)	Different percentages (row, column, cell), group comparisons, correlation and causation, Simpson's paradox; Critical thinking; Posing adequate statistical questions; Exploring meaningful datasets with Fathom
Students working on mini projects (6-10)	Statistics about the world; German hospital statistics; Inequality in the world; Daily habits of US citizens; German accident statistics
Gender pay gap (GPG) project (11-14)	Getting to know the GPG discussion/the adjusted and unadjusted GPG, Exploring real data about GPG and presenting the results via PowerPoint
Concluding session (15)	Summing up and closing discussion

In sessions 2-5 the statistical knowledge of the participants will be refreshed. At first we will refresh the basics of descriptive statistics, and then discuss critical thinking elements with regard to newspaper articles and statistical graphs with our participants. We will discuss the PPDAC-cycle and the generation of adequate statistical questions and apply the participants' refreshed knowledge in an exploration of meaningful data using Fathom. Presenting the findings will conclude the fifth session. In sessions 6-10 our participants will work on new mini projects in teams of two. These mini projects will be a combination of the students' sessions (4-9) and the small PCS projects (14) from the last cycle. Each mini project session will last 90 minutes and will be led by student leaders. In contrast to the last cycle, student leaders will get a ready-for-use worksheet in advance for use during the session. In these 90 minutes the participants will explore real and meaningful data with different tools (amongst others Fathom, Gapminder, CODAP) in a broad range of civic statistics data along the worksheet. Taking into account the national level, two of the small projects will be devoted to the hospital and the accident situation in Germany. Two other small projects will be about the inequality in the world, using CODAP and Gapminder for the specific explorations. Another small project will cover the analysis of the daily activities of US citizens using a specific free online tool. The gender pay gap project (sessions 11-14) will be realized in the same way like in winter term 16/17. Our 17/18 course will close with a closing session (session 15) summing up the course and discussing possible implications for mathematics classrooms.

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