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Learning Statistics by Doing Sociology

Applying Inquiry-Based Learning in Undergraduate Methods Courses

ABSTRACT

This article presents a teaching concept for two statistics courses in a Sociology B.A. program based on the concept of research-based teaching and learning. At the heart of these courses are practical exercises and homework assignments in which students use actual data to answer consecutive questions on income inequality. The main objectives of this approach are to motivate students, to highlight the importance of statistics and data analysis for sociologists, to improve their programming skills, and to train statistical and sociological thinking. Empirical results indicate that implementing this approach achieved the first two objectives but requires adjustments to further enhance students' programming and higher-order thinking skills.

Key words: inquiry-based learning – statistics – social sciences – social inequality

ZUSAMMENFASSUNG

Dieser Artikel präsentiert ein Lehrkonzept für zwei Statistik-Kurse im Bachelor Soziologie basierend auf dem Konzept des forschenden Lehrens und Lernens. Das Herzstück dieser Kurse sind Übungskurse und Hausaufgaben, in denen die Studierenden mit aktuellen Daten aufeinander aufbauende Forschungsfragen zu Einkommensungleichheit beantworten. Ziele dieses Lehrkonzeptes sind es, die Studierenden zu motivieren, ihnen die Bedeutung der Datenanalyse für die Soziologie aufzuzeigen, ihnen Programmieren beizubringen und ihr statistisches und soziologisches Denken zu trainieren. Eine empirische Evaluation zeigt, dass dieses Konzept die ersten beiden Ziele erreicht hat, Kompetenzen der Studierenden in Programmieren und abstraktem Denken jedoch verbessert werden sollten.

Schlagwörter: Forschendes Lehren und Lernen – Sozialwissenschaften – soziale Ungleichheit – Statistik

Introduction

> "The need for quantitative skills has intensified, and sociology provides one arena where students can apply these skills to real life settings and phenomena." (ATKINSON & HUNT 2008: 3).

This work introduces a structured, inquiry-based approach to teaching statistics, specifically tailored for undergraduate sociology courses. Inquiry-based learning (IBL) is a cluster of student-centered teaching and learning approaches emphasizing the connection between teaching and research. In this approach, students learn disciplinary knowledge and the skills necessary to generate such knowledge by actively working on research activities.

This redesign aims to connect research methods and statistics to substantial questions to demonstrate why sociologists need statistics and how they apply it. It connects statistics to socially relevant topics in research on social inequality, focusing particularly on gender differences in income and labor force participation. It teaches students data analysis using current data and software. This increases student motivation and engagement with statistics. Moreover, it fosters theoretical thinking and highlights the connection between theory and data. The secondary aims of the redesign were to even out the workload for students throughout the semester, update and improve assignments and materials, and strengthen students' command of statistical software.

The paper proceeds by presenting the fundamentals of inquiry-based learning before reviewing existing literature on common problems in statistics education and how inquiry-based learning has already been used to improve statistics and sociology classes. I then turn to our course objectives and how they fit into the curriculum. The most significant section analyses how we implemented inquiry-based learning in these courses and explains our choice of gender differences in income as the focus for the assignments. Based on exam results from previous years and structured group interviews, we achieved our goals to motivate students and teach them why and how sociologists use statistics. Nevertheless, we still need to improve students' higher-level thinking skills. Finally, I summarize the article and discuss potential next steps to achieve the remaining goals.

Inquiry-Based Learning

'IBL' describes a cluster of strongly student-centered learning and teaching approaches in which students' inquiry or research drives the learning experience. Students conduct small- or largescale inquiries that enable them to engage actively with disciplinary or interdisciplinary questions and problems. Learning takes place through an emergent process of exploration and discovery. Guided by subject specialists and those with specialist roles in learning support, students use the scholarly and research practices of their disciplines to move towards autonomy in creating and sharing knowledge (LEVY et al. 2011: 6).

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Inquiry-based learning (IBL) is a general paradigm in university teaching that emphasizes connecting learning and research, ideally through student research projects (HEALEY & JENKINS 2009: 6). IBL enables students to experience knowledge-creation processes themselves. Nonetheless, there are different ways to connect research and learning, and no single solution exists for every situation. Healey and Jenkins (2009) therefore developed a typology based on two dimensions: whether the focus is on research content or the research process and whether students are the audience or active participants shown in Figure 1 (see following page). Not only do different courses need different styles of connecting teaching and research, but it is also most effective to combine and interlink the different cells of the matrix. Within a curriculum, for example, lectures typically teach fundamental concepts, results, and current questions of a field before seminars go into detail and discuss current issues of the field. In contrast, practicals teach how to use the methods to answer the respective questions (KLÖBER 2020). Healey and Jenkins (2009) emphasize the importance of active ways of learning and plead for broader adoption of teaching methods where students are participants.

While some only consider the upper right quadrant IBL, mandating student autonomy in the research question and the process to answer it, others support a broad definition (KLÖBER 2020). In the definition adopted here, IBL does not necessarily mean that students pose the questions that they subsequently answer nor that the knowledge is necessarily new (although it is new to students) (LEVY et al. 2011: 6). The goal is for students to experience and learn about research in the discipline engagingly and actively.

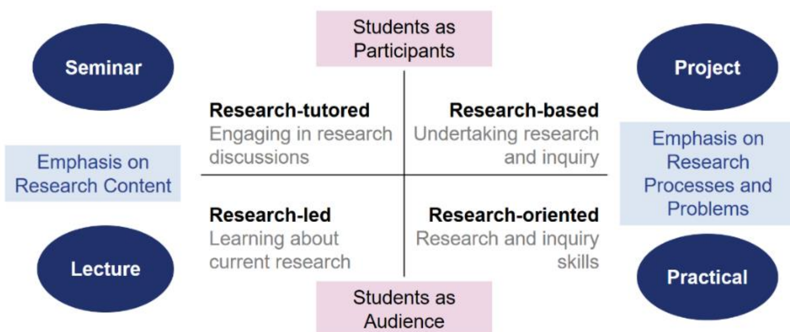

Figure 1
Four Ways to Connect Research to Teaching
Schema based on Healey and Jenkins (2009: 7), as illustrated by Klöber (2020: 14)

Healey and Jenkins (2009: 22–23) distinguish between structured, guided, and open undergraduate research projects depending on the level of student autonomy. In structured IBL,

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the lecturers set the questions and methods, while in guided IBL, the lecturers let the students answer set questions autonomously. The goal should be for students to increase their autonomy over the curriculum.

Inquiry-Based Learning in Sociology and Statistics

"Asking questions and learning to look for answers should be the core of any sociology curriculum" (Atkinson & Hunt 2008: 6). Therefore, IBL is a teaching paradigm well suited for teaching sociology since it trains deeper level thinking and enables students to construct knowledge independently (id.). IBL is particularly well suited for methodology and statistics courses, as they focus on the research process: how we can answer our questions of interest.

Methods and statistics classes should not introduce statistics in isolation. Unfortunately, students often perceive courses in methodology and statistics are not related to their other courses and research in general (Sernau 1995; Howery & Rodriguez 2006; Atkinson & Hunt 2008). This observation highlights a potential shortcoming of statistics courses. Not only does it waste didactical potential, but also statistical modeling and the interpretation of statistical results require substantive knowledge. Statistics is primarily a tool to describe social phenomena and to test competing theories. The relation between statistics and theory is essential in teaching statistics to sociologists (Timothy 2005): theory must specify valid statistical models and justify its respective assumptions before analysis. After analysis, theory is necessary to interpret results and discuss their relevance to the question, the underlying theory, and the field.

A particular advantage of IBL is to be able to combine statistics with substantive content. Most social science students choose their field of study because they are interested in the substantive contents, for example, migration, social inequality, or social change. Although not all social science students feel this way, many express that they struggle with math or even fear statistics (DeCesare 2007; Condron et al. 2018). They expect to be bad at, bored by, and/or disinterested in statistics (Bailey 2019: 367). Researching a substantive topic can also improve students' understanding of sociology as an empirical discipline and the interplay of theory and statistical model building (Howery & Rodriguez 2006). Students also often need help seeing data as an aggregate instead of a collection of individual data points (Garfield & Ben-Zvi 2007: 382–383), which is particularly problematic for sociology as the discipline justifies its existence with emergent phenomena at the societal level.

Empirical research on statistics education has shown that achieving a deep understanding of statistical concepts is challenging and takes time, even with well-designed programs (Garfield & Ben-Zvi, 2007: 379). The American Statistical Association (2016) guidelines for university courses, therefore, strongly suggest teaching statistics using active teaching methods and thinking of data analysis as a student skill that applies to many problems instead of statistics as an isolated subject in its own right. Specifically, they recommend emphasizing statistical literacy and developing statistical thinking, using real data, stressing conceptual understanding rather than mere knowledge of procedures, fostering active learning in the classroom, using technology for developing conceptual understanding and analyzing data, and using assessments to improve and evaluate student learning. Bailey (2019) also recommends making small steps. Only teach the methods necessary to answer a question or apply to common problems. He also advises to work on substantive issues with real data. “As instructors of statistics, it is our job to make the subject less intimidating, more interesting, and more useful” (BAILEY 2019: 370).

Multiple implementations of IBL or student projects in statistics classes have been reported to have been successful. Specifically, students show higher motivation and engagement, a more thorough understanding of the content, and better grades in assessments (e.g., SMITH 1998; HOWERY & RODRIGUEZ 2006; GARFIELD & BEN-ZVI 2007; LOVEKAMP et al. 2017).

Context and Content

> ”Research and teaching at the School of Social Sciences takes an empirical-analytical approach, which is informed by theory and relies on quantitative methods.” (UNIVERSITY OF MANNHEIM 2023)

The two modules described in this section are part of the BA Sociology at the University of Mannheim, Germany. The University of Mannheim focuses on the economic and social sciences. Research at this institution is typically based on methodological individualism (the epistemological conviction that social phenomena should be explained referring to the beliefs and actions of individuals) and extensively uses quantitative methods. This outlook on sociology is reflected in the curricula, too. However, it is questionable how aware bachelor’s students are of the specific sociological outlook of this institution at the time of enrollment. The methods education in the BA Sociology program at the University of Mannheim begins in the first semester with courses on data collection, an introduction to sociology as a discipline, and sociological theory. This article considers the mandatory statistics modules in the BA sociology program, which are taken in the second and third semesters. Afterwards, students may choose specializations that work with more specialized methods such as network analysis or computational social science or choose more substantive courses, particularly in social psychology, migration and integration, and social inequality. The curriculum has no mathematics and programming courses, so the students only have the mathematical and programming skills they acquired in school. Their command of mathematics is very heterogeneous, and many students have no prior experience in programming.

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The two statistics modules comprise three classes each: a lecture, practicals, and tutorials. The lecture motivates and introduces theoretical statistical procedures. The tutorials, taught by advanced students, serve as a "safe space" for students to ask questions, calculate statistics by hand, and prepare for the exam. They also discuss solutions to student assignments in the substantive field of income inequality and employment. The practicals show how to perform the statistical procedures using statistical software and connect statistics and substantive theories and interpretations. They prepare the students to be able to work on the assignments. The practicals and assignments are at the heart of implementing IBL in statistics education.

Cognitive Learning Objectives

In statistics education, scholars often differentiate between statistical literacy, reasoning, and thinking, each representing a transition to a higher order of thinking (GARFIELD & BEN-ZVI 2008: 67–68). Statistical literacy refers to understanding and using the fundamental statistical language and tools. Statistical reasoning is making sense of statistical concepts and interpreting statistical results. Statistical thinking finally refers to knowing which method to use for given questions and data, statistical theory and limitations, and planning how to solve statistical problems.

In statistics courses for social scientists, all three are relevant but are applied to phenomena from the respective discipline. Therefore, the meanings of the results for society and sociology are also relevant. This requires students to be critical sociological thinkers, think statistically, and apply general higher-order thinking simultaneously (KANE & OTTO 2018).

Explaining social phenomena requires multivariable thinking: "multivariable thinking is a broader pattern of thinking that appreciates [how] several variables are often interrelated in complex ways. Multivariable thinkers can employ an intuitive sense of concepts such as confounding, mediation, association, interaction, and causality to create a more complete understanding of relationships in their data" (ADAMS et al. 2021: 125). Being able to conduct research requires computing skills and familiarity with statistical software as well (NOLAN & TEMPLE LANG 2010; JOHNSON & GLEIT 2022): students need to know basics of how data is stored and processed by computers, how to manipulate and transform data as well as how to organize files and directories.

Second Semester

The students' first module in statistics, entitled *Datenanalyse* ("data analysis"), takes place in the second semester. This module uses survey data to describe samples and populations. However, in the beginning, considerable time is spent getting started with statistics and STATA, a software environment for statistics and data analysis. In the end, the students learn how to analyze experimental data. The learning goals are:

After completing the lecture and practical, the students can...

- name the fundamentals of the scientific method
- differentiate between different measurement scales and state their significance for statistical analyses
- transform substantive questions into statistical calculations
- read data into STATA and transform them
- calculate descriptive statistics by hand and in STATA
- create data visualizations in STATA and interpret them
- make statements about populations from samples using inferential statistics
- differentiate between correlation and causation
- analyze simple experiments

Third Semester

In the third semester, the module *Multivariate Verfahren* ("multivariate statistics") introduces students to fundamental techniques in multivariate analyses, particularly analysis of variance (ANOVA), linear regression, and binary choice models. These methods are primarily used to test theoretical hypotheses in the social sciences. However, the exercises also advance students' command of statistical software by using scripts instead of the command line. More importantly, the module places a strong emphasis on open science, replicability, and documentation, which are crucial aspects of academic research. The learning objectives are:

After completing the lecture and practical, the students can…

- outline the importance of multivariate statistics for the social sciences
- build and criticize statistical models based on theories
- write STATA do-files and document projects according to open science standards
- explain optimization using the least squares method
- explain ANOVA and regression models and execute them in STATA
- interpret results from regressions and ANOVA sociologically
- use regression for mediation and moderation analysis
- recall regression assumptions and check if they are violated
- explain binary choice models and execute them in STATA

Social and Motivational Learning Objectives

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Students work on consecutive assignments throughout the semester and are encouraged to collaborate in small teams to achieve two goals. First, research indicates that cooperative learning can increase academic performance in general (COHEN 1994) and specifically in statistics education (GARFIELD & BEN-ZVI 2007: 377–378). Second, this teamwork prepares students for the job market, where they will usually work in teams. E. G. Cohen (1994: 4) presents two ways in which groups can help individual members learn the course material. They can provide assistance to one another and share ideas and strategies. This course uses groups for both reasons. The small groups require the students to continuously work with the course materials because there is a social expectation not to let their colleagues down. Moreover, they need to be more engaged with the material to be able to discuss it with others. The students are not alone when working on difficult tasks and they experience frustration, which can help mitigate anxiety and disengagement (MACHESKI et al. 2008). Cooperation requires the cognitive skills to perform the tasks at hand and social skills (COHEN 1994).

Additionally, the redesign increases student motivation and engagement. Previous research on statistics classes in social science programs shows that students often perceive methods courses as unconnected to their other courses (SERNAU 1995; HOWERY & RODRIGUEZ 2006; ATKINSON & HUNT 2008). By applying statistical methods to current data in a research project of social and sociological importance, students see how and why statistics is useful to sociologists. As most social science students choose their program for its content, engaging with substantive content and the research process should make them more understanding and motivated to learn statistics.

How We Apply Inquiry-Based Learning

We adopted IBL "as a form of active learning in which students carry out research-like activities to explore and master an existing knowledge-base" (LEVY et al. 2011: 6). While the lecture presents problems and the statistical theory useful to solve them, students apply the procedures and tools in the practicals and assignments in STATA answering questions on social inequality. The lecture (and tutorials) are exclusively situated in the research-oriented quadrant of the typology of Healey and Jenkins (2009) where students are typically an audience (for an thematic overview of the courses, see appendix).

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Practicals

The practicals are at the heart of the IBL implementation and switch between research-oriented and research-based modes (see figure 1). The practicals repeat and summarize the content of the lecture and apply the statistical procedures in statistical software so that students can apply them on their own in-class exercises and assignments. The practicals therefore incorporate different teaching modes in each session and try to foster an intuitive understanding of the concepts by using visuals and examples. They present how to do a new procedure or interpret results. Second, they practice the new techniques with in-class exercises in small groups with help from the instructors. After the practicals, student groups should be able to work on the assignments without supervision. As the in-class exercises and assignments are given while the students do their own analyses, the course implements a producing/discovery-responsive style of student research activities: they engage with lines of inquiry and the knowledge-base of the discipline framed by instructors to learn how they can answer these exemplary questions. Students will become statistically literate, able to understand statistical results, and develop as statistical thinkers, capable of answering questions with suitable statistical procedures, by continuously discussing new and more complex research questions and statistical findings.

As the teaching modes are diverse, the role of the instructor varies considerably within a session. First, they fulfill the role of a presenter and explainer of new concepts and procedures. Where appropriate, they try to engage and moderate student discussions, for example by asking questions and showing graphics or results in need of an interpretation. Furthermore, instructors encourage and help students during the in-class exercises. Finding the right balance between student autonomy and required help is crucial. Finally, when discussing solutions to the in-class exercises, instructors are moderators again.

Assignments and Substantive Content

With the assignments, we implement a structured style of IBL where the questions to be answered and the tools with which the students answer them are provided. The assignments' importance is that the students conduct research activities, practically use statistical software, and get to know data.

Although some courses utilize student data, ideally from those taking the class (e.g., LOVEKAMP, SOBOROFF & GILLESPIE 2017), to also create a coherent course on quantitative methods including data collection, we decided against this approach. This decision is partly due to organizational concerns, as there is a separate module on data collection. However, we primarily want to connect research methods and statistics to substantive topics of interest and work with actual social science data.

We place the assignments and many examples used in the practicals substantively in the literature on income inequality. This allows for having relevant variables of all scales (e.g.,

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gender as nominal, educational level as ordinal, and income as metric). The topic of inequality is also inherently a feature of the aggregate, speaking to both sociologists and statisticians. Sociology as a discipline justifies its existence on the notion that society shows new emergent patterns separate from individuals due to relations, groups, and interdependencies. In teaching statistics, students often need help perceiving the data as an aggregate entity in its own right instead of a collection of individual data points (GARFIELD & BEN-ZVI 2007: 382–383). In the study of inequality, the form of the distribution and the variability between individuals and groups is central. Searching for patterns within the noisy data and explaining them becomes the main objective. At the same time, debates on inequality are well known to students from media, their experiences, and potentially other courses in the curriculum. They have, therefore, knowledge about the issues that allow them to think about potential causes for themselves.

Finally, inequality is a topic that is still actively researched and receives considerable public interest. Students are likely interested in it and care about it. Building upon this prior knowledge and promoting students to construct knowledge themselves is known to enhance deeper and more sustainable understanding (GARFIELD & BEN-ZVI 2007: 387–388) and courses using similar teaching methods have already successfully been conducted in social stratification (e.g., SERNAU 1995).

In both courses, we extensively use survey data from the German General Social Survey 2018 (GESIS LEIBNIZ-INSTITUT FÜR SOZIALWISSENSCHAFTEN 2019). The assignments tell a coherent narrative, with results from the previous assignment motivating further investigation in the subsequent assignments. The students will also learn about income inequalities and potential explanations throughout their research. These "cliffhangers" are also intended to increase student motivation, keep them engaged, and give them a sense of the research process's cyclical and preliminary nature.

Second Semester

The first assignment asked students to create frequency tables, univariate descriptive statistics, and graphics of the respondents' monthly net income, educational levels, etc. There are considerable differences between population members, which follow typical patterns and distributions. We then extend the use of frequencies, descriptive statistics, and graphics to create group comparisons by gender to establish multi-variable thinking (ADAMS et al. 2021) and sociological concepts like group inequalities early on. This also helps students to interpret graphics and descriptive statistics, as comparisons are likely more accessible than describing features of a distribution without a reference or interpreting a single statistic. These comparisons reveal that women earn lower incomes than men. This establishes the fundamental puzzle that accompanies the two modules: why do women earn lower incomes than men? It also establishes the typical order of social research: before thinking about explanations, there must be a descriptive observation that requires explanation.

Further descriptive statistics reveal that men and women do not differ in educational achievements but in labor market participation: women work less often, and many work

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part-time. The students then construct an approximation of hourly wage from the variables on net income and the hours worked per week to see whether the difference in working hours by gender can explain the income differential. This further trains students' multi-variate thinking, and provide them with an initial understanding of how sociologists develop and test potential explanations. Additionally, students extend their practice of data manipulation. Gender differences are also present in wages, even though differences are less pronounced.

So far, we have only worked with samples. Could it be that we have just been unlucky, and that the observed group differences are merely a result of random chance? Can we make inferences from the sample to the population? To ask these questions, we review the fundamentals of probability theory before turning to statistical inference. It is very unlikely that our observations are just due to random chance, and we can infer that these inequalities are also present in the population.

Ultimately, students learn to study bivariate associations more formally using cross-tables and correlation. Cross-tables and hypothesis testing allow us to analyze simple experiments. At the end of the second semester, the students test the explanation that women are discriminated against in the labor market and, therefore, need to settle for worse working conditions, although they are equally qualified as men. To do so, the students replicate the analysis of Birkelund et al. (2022). They analyze a field experiment on hiring discrimination by gender using data collected by Lancee et al. (2021). This constitutes our first formal test of a theoretical explanation and allows us to discuss the advantages of experiments, which are different from survey data.

The experiment shows that women are not disadvantaged in the hiring stage. Quite the contrary, men receive fewer callbacks than women. Discrimination is, therefore, not responsible for the observed gender differences (at least not in the hiring stage).

Third Semester

Ending the first semester with a null finding motivates continuing the topic the following semester. If employer discrimination in hiring is not the issue, what could it be?

We can then consider gendered educational and occupational choices, labor force status, childbirth, social norms, etc. However, these potential explanations are more difficult or impossible to manipulate experimentally. To test these explanations, we need more advanced statistical tools to differentiate between multiple influences simultaneously: ANOVA and regression.

However, first, students learn how to work with scripts and learn why replicability and documentation are essential to social research. The first assignment asks the students to write their code for last semester's assignments into a documented script. The second practical session and assignment deviates from the standard theme as we discuss causality, the role of theory in explanations, and the relation between theory and data analysis more explicitly that week. For the assignment, students read a chapter from a textbook and write a summary of the relation between theory and data analysis. We considered a separate session on the fundamentals of sociological methodology and the philosophy of science useful for clarifying the uses and limitations of data analysis for explanatory research questions. Students should know why data analysis, especially a single study, can never prove a theory true. Scientific knowledge is always preliminary, and there are differences in how confident we can be in our current knowledge. This affects how we can interpret results from empirical tests of explanations in the rest of the semester. The assigned book chapter (COHEN 1989: ch. 13) explains some of the reasoning in more detail, and the reading and writing a summary ensures that they engage with the abstract material in depth.

The subsequent assignments then further explore explanations for income inequalities, how to substantially interpret ANOVA and regression, and how to test for theoretically expected relations such as moderations and mediations, using regression analysis. In these sessions and assignments, we focus on theoretical and statistical thinking, exploring how we can relate the two: how can we test this explanation with our available data and tools. One assignment is dedicated to probability theory again to lay the foundations for the following sessions and assignments on inference in the regression context and regression assumptions. Only if our methods are appropriate and the results are unlikely to result from sampling can we have some confidence in our tested explanations.

The next session and assignment are dedicated to regression diagnostics using residual analysis. We critically examine whether the assumptions made by our statistical models hold (as far as we can tell) and how violations of these assumptions might affect results. This again exemplifies the culture of academic criticism and requires statistical thinking at a very abstract level. The typically right-skewed income distribution leads to violations of regression assumptions that can be mitigated by extending regression. Extensions introduced in the following practical and assignment include logging variables and modeling nonlinearities with polynomials, interactions, and dummy variables. These extensions increase the possible uses of linear regression and explain why this method is so standard in the social sciences. Another session teaches the fundamentals of statistical model building based on theory and causal diagrams (directed acyclical graphs). This session also introduces mediation analysis using regression.

Last but not least, regression assumptions motivate using binary choice models for dichotomous dependent variables. The assignment on binary choice models tests social norms and household situations as reasons why women might only work part-time. By the end of the semester, students will not only have gained many insights into the research field of social inequality but also have had the opportunity to practice theoretical thinking, build statistical models based on theories, interpret statistical results, and critically assess these models and results multiple times with increasing difficulty and abstraction.

Exam Results and Group Interviews

One way to assess whether the redesign improved students' learning outcomes, particularly the cognitive learning objectives, is to look at trends in the exam grades. Throughout the reported time frame, the exam style remained the same, making comparisons between years possible. Nevertheless, each exam is different, and there is variation between cohorts. Only if there is a clear deviation from previous trends after the implemented changes can an effect be credibly credited to the change in teaching concept.

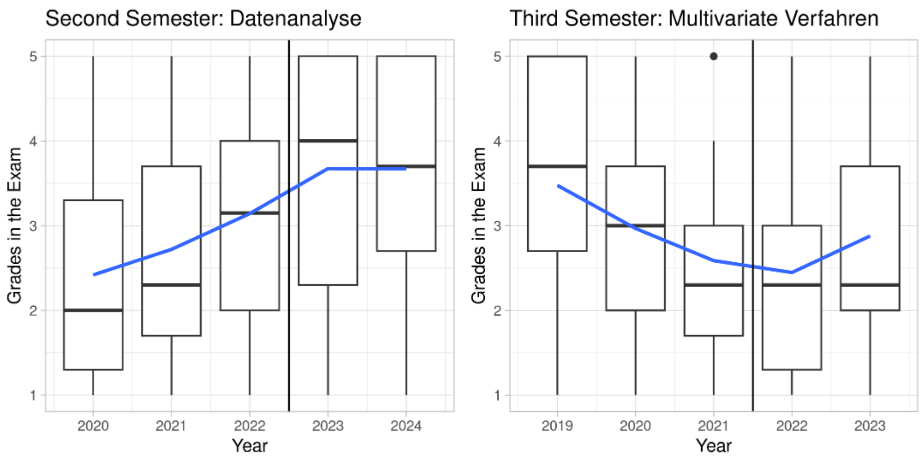

Figure 2: Trends in Exam Results
The two subfigures show the distributions of grades in the final exams of *Datenanalyse* and *Multivariate Verfahren*, respectively. In each subfigure, the boxplots depict the grades of the last five exams. The vertical bars indicate the implementation of the new teaching concept. Beginning in fall 2022, classes used the new concept. The blue line connects the average grades of each class. In the German grading system, 1 represents the best grade, 4 is the worst passing grade, and 5 indicates failure to pass the exam.

Unfortunately, such a clear discontinuity is not observable in figure 2. Surprisingly, while grades before the change worsened in *Datenanalyse*, the grades in *Multivariate Verfahren* improved. After introducing the new concept, grades in *Datenanalyse* continued to get worse. Grades in *Multivariate Verfahren* remained comparable to previous years or got slightly worse. Therefore, there is neither credible evidence that the redesign improved nor hurt learning outcomes.

To assess whether we achieved the goals of the redesign in more depth, I conducted structured group interviews in the four practicals. By interviewing each practical, I could cover most students registered for the courses. Even though not all students participated in the group interviews (as each practical consists of about 20 students), students showing

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different levels of achievement and engagement in the class participated. I conducted these interviews at the beginning of the third semester, so the results are based primarily on the student experiences of the second semester.

I first asked the students about their expectations before taking the statistics classes and how they have perceived the courses up to this point. Student responses mirror the existing research that multiple students had fears going into the course as they do not consider themselves good at math and have no prior programming experience. Some students say that their anxiety was decreased throughout the class, while others reported often feeling “lost.” Students report spending a lot of time on learning and assignments compared to other courses. The classes were moving fast, and there was not enough time for repetition. Especially programming came too short in practical sessions before the respective commands were needed in the assignments. A few said they did not prioritize STATA as programming was not part of the final exam.

The second question asked whether the ongoing example of income inequality motivates students in the class and helps them understand how and why sociologists use statistics. All students who responded to this question highlighted that working with current data and a sociological question helps them understand abstract statistical concepts and how and the relevance of statistics to sociologists.

Some students were motivated by the example, even if they were uninterested in the chosen topic. One student explicitly stated that they chose sociology for the substantive topics and connecting substantive examples and statistics makes it more accessible and gives them a “sense of direction” in the statistics class. However, a few students said they did not feel particularly motivated by the ongoing example. Some students highlighted the golden thread connecting the classes, while others were unaware that the substantive results were building on each other. They treated them merely as independent assignments. When explicitly probed on it, students said that applying statistical methods using statistical software did not improve their understanding of the method itself, only their usefulness and applicability.

Regarding their perception of learning achievements, most students who responded were more satisfied with their statistics progress but less with their programming skills. They again highlighted that they worked on statistics because of the exam, which was not true of programming. Nevertheless, some students were satisfied with their progress in STATA as well. Interpretation of statistical results and theoretical thinking came too short for many students and would need more practice (however, interpretation and theory took on a more critical role after I conducted the interview). One student stated that media reports on the topic might have influenced their interpretation more than the actual results.

Despite explicitly asking about it, several students noted the importance of working on the assignments in groups to distribute the workload and help each other. They perceived the collaboration with their peers as helpful and the relationships with lecturers as friendly and open.

Discussion and Conclusion

In this article, I have presented a fundamental redesign of the teaching concept of two statistics courses for undergraduate sociology students. This redesign was based on the paradigm of inquiry-based learning (HEALEY & JENKINS 2009; LEVY et al. 2011), which emphasizes how teaching can and should connect to research. Ideally, students learn actively by performing research activities themselves.

The redesign considers particularly the practicals and assignments that apply the statistical methods presented in a lecture to the research field of social inequality. The assignments form a consecutive narrative where the answers to previous assignments motivate further investigations in the current assignment. This mimics the research process, motivates students to stay engaged, showcases how and why sociologists use statistics, and trains students to think sociologically about these methods and their results. The practicals summarize the statistical theory, apply it to the respective problems, and provide the software skills so students can solve the assignments in groups without supervision. Therefore, as we are teaching early undergraduates, we adopted a highly structured form of IBL, which focuses on the research process. However, students switch between being an audience, participating in discussions, and answering research questions using statistical software.

Overall, the redesign is a partial success. Many students reported in the group interviews that they appreciate working with data on an important topic. Many but not all students were motivated by the examples and understood the usefulness of statistics for sociologists. Some also realized that the assignments work on consecutive questions and mimic the research process. Nevertheless, there is no improvement in grades attributable to the redesign. Inferred both from which exam exercises went poorly and the subjective assessment of achievements in the group interviews, students have the most difficulty interpreting statistical results sociologically and converting a problem into a statistical calculation (statistical thinking). It is our most challenging aim (GARFIELD & BEN-ZVI 2007: 379), but teaching higher level thinking remains an area we need to improve. Similarly, many students feel less confident with programming and statistical software. Students report a high workload in the assignments and often feel “lost.” Some students did not care for programming as they prioritized the type of questions asked in the exam. They also prepared more for calculations than for interpretation regarding the exam. In summary, while we achieved a better understanding of the need for statistics and student motivation with the assignments, we have not achieved substantial improvements in higher-level thinking and programming.

However, these shortcomings are not faults of the over-arching concept. The consecutive assignments provide ample opportunities to train higher level thinking and connect sociological thinking to statistical model building and interpretation of results. Many students urged for more help in programming, which few have prior experience in, complaining that they were not ready to solve the assignments independently. They will likely cut corners in interpretation if they need to spend long hours getting the programming done. Our primary ideas to improve interpretation skills and statistical thinking are to assign more time for the practicals to in-class programming exercises so that students are better prepared for the assignments, provide programming help in the form of cheat sheets, and check the assignments for potential sources of confusion. Another idea might be to give student groups detailed feedback on their submissions instead of a general discussion of the assignment in the plenary.

In conclusion, the presented idea to accompany a statistics lecture with consecutive student assignments answering questions about social inequality using timely data and statistical software has helped students understand the usefulness of statistics and experience the research process. The constant work on sociological problems with increasingly advanced statistical tools holds ample opportunity to teach sociological and statistical thinking. However, achieving a deep understanding of statistical concepts and relating them to social science thinking is arguably the most challenging aim of statistics education.

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Appendix

1. *Datenanalyse*

Week	Lecture	Practical	Research Questions in the Assignments
1	Introduction	Introduction to STATA and the ALLBUS	
2	Frequency Tables and Diagrams	Scales and Frequency Tables	What are the frequencies of income and type of employment?
3	Features of Distributions, Measures of Centrality	Visualizations of Frequencies	For which reasons are respondents unemployed? What is the distribution of education? Are there differences in the income distributions of men and women?
4	Measures of Dispersion	Measures of Centrality	What is the most common income in the sample? What are mean and median incomes? Which proportion of our sample is considered poor (less than 40% of national median income)? With which income are you part of the top 5% of the income distribution?
5	Probability and Random Variables	Measures of Dispersion	How dispersed is the income distribution? Which measures would change in a scenario where the top 2% of employees of a company would get a bonus?
6	Normal Distribution	Group Comparisons and Boxplots	Are there differences between men and women in incomes and in wages? What is the gender wage gap in our sample?
7	Confidence Intervals	Probability and Distributions	(unrelated exercises on probability)
8	Hypothesis Testing 1	Confidence Intervals	Can we generalize our previous findings from the sample to the population?
9	Hypothesis Testing 2	Hypothesis Testing	Is the difference in income and wages between men and women statistically significant?

10	Crosstables	Crosstables	Are there educational differences by gender?
11	Measures of Correlation 1	Chi² and Cramer's V	Are the educational differences by gender statistically significant?
12	Measures of Correlation 2	Experiments	Can discrimination in hiring explain gender differences in employment outcomes?
13	Measures of Correlation 3	Correlation and Scatter Plots	What is the relationship between weekly workhours and monthly income?
14	Q & A	Q & A	

2. *Multivariate Verfahren*

Week	Lecture	Practical	Research Questions in the Assignments
1	Causality	Repetition of Stata, Do-Files	Repetition and summary of the results from last semester
2	ANOVA	Causality, Theory in Empirical Research	(unrelated exercises on causality and methodology)
3	Linear Regression	ANOVA	Can education and gender explain incomes?
4	Ordinary Least Squares Estimation	Linear Regression	Can differences in gender and age predict differences in workhours?
5	Inference in Regression	Interpretation of Regression Coefficients, Categorical Predictors in Regression	Can differences in education and age predict differences in incomes?
6	Gauss-Markov- and Central Limit Theorems	Standard Errors and Coefficient Plots	Can social and ethnic origin predict incomes?
7		Repetition Probability	(unrelated exercises on probability and the central limit theorem)
8	Hypothesis Testing in Regression, Model Fit	Gauss-Markov- and Central Limit Theorems	

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9	Regression Diagnostics 1	Hypothesis Testing and Confidence Intervals for Regression Coefficients	Are the coefficients for the effects of workhours and education on incomes statistically significant?
10	Regression Diagnostics 2	Regression Diagnostics	Do our previous regressions violate OLS assumptions?
11	Extensions of Linear Regression	Extensions of Regression, Moderation Analysis	Can we mitigate the observed violations of OLS assumptions by using logged income as a dependent variable and age squared as a predictor? Does the effect of workhours on income differ by gender?
12	Binary Choice Models 1	Testing Theories, Mediation Analysis	Which theories are currently discussed for the existing gender inequalities in incomes? Can we test some of them with our data?
13	Binary Choice Models 2	Binary Choice Models	Can social norms and household composition explain why women work part-time more often?
14	Q & A	Q & A	