Syllabus math camp

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Mathematics for Political and Social Scientists

The objective of this 10-hour workshop is to provide a refresher into basic algebra and calculus. Knowledge of algebra and calculus is increasingly crucial in quantitatively-oriented political and social science and allows researchers to better understand, manipulate and develop statistical methods as well as formal theory. This knowledge will also help researchers to better follow quantitative methods courses. Next to providing a refresher into basic algebra and calculus, the workshop discusses examples of their use in political and social science practice.

The workshop will be divided into 4+1 blocks, one for each of the five workshop days. The first block will refresh basic mathematical notions related to arithmetic, notation, and calculus. The second block aims to familiarize students with common equations present in actual social science research and introduce derivatives and extrema. The third block introduces students to basic notions of probability and random variables and most common probability distributions. The fourth block focuses on vectors and matrices, their basic properties, and their utility in social science research. Finally, the last block sums up the previous blocks and adapts to students' questions/concerns.

Every day, students are required to do short proposed exercises in the last 15 minutes of the class. On the next day, one selected student will solve the exercises. The aim is not to take time apart from the 10-hour workshop. The workshop has two main objectives: first, to familiarize students with basic notions of arithmetics, calculus, probability, and algebra; and second, to help students self-evaluate themselves and be aware of accessible materials that can help them improve their background mathematical knowledge.

1st Session - Arithmetic, calculus and notation

The first session introduces basic concepts necessary to build on subsequent blocks. First, we briefly present the difference between concepts and variables, an important distinction with significant implications in social sciences. After the introduction, we start the maths lecture by discussing a set, seeing different sets, and relating them to social

sciences research. Then, we refresh some important basic operators likely found in social science research. We also raise awareness on variables with different measurement levels and how the information is given. After, students will be asked to complete a set of short in-class exercises based on previously discussed materials. One of the students will be selected at the beginning of the 2nd session to solve them. Lastly, we will introduce students to the second session by discussing functions and different equations usually present in social sciences. The first session consists of the following topics:

- Short introduction. Why maths in social sciences.
- Variables, constants, concepts.
- Sets. Ordered (datasets) and unordered; difference, complement, intersection, union; Venn diagrams and scope conditions; relations (<,>,=)
- Operators. Table, introduce to most important operators (and less common)
- Arithmetics review
- Level of measurement. Nominal, ordinal, interval, ratio
- Ratios, proportions, percentages
- Exercises with sets, arithmetic operations.
- Intro to functions and equations. Utility. Linear, exponential, logarithmic functions with social science examples.

There are no readings for the first session

2nd Session - Derivates and Extrema

- Derivatives. Explanation, definition, systematization and shortcuts. Why are they so important.
- Extrema. Local and global extrema. Critical and inflection points. Concavity and convexity.
- Maximization. Utility example, Minimum Square Error example.
- Multivariate functions and partial derivatives.
- Short, intuitive, introduction to integrals.
- Exercises. Calculate derivatives, maximum and minimums, partial derivatives.

Recommended reading

- Moore, W. H., & Siegel, D. A. (2013). A mathematics course for political and social research. Princeton University Press. Pgs. 88-91.

3rd Session - Probability and Random Variables

The third session will introduce the basic notion of probabilities. The session will be divided in three distinct part. Firstly, students will be introduced to the basic concepts surrounded classical probability theory such as events (random, simple, compounds), independence and exclusiveness, probability space, and conditional probabilities. Secondly, notions of random variables and distributions will be discussed with a particular focus on the probability mass function and its parameters with examples of the normal distribution. Finally, some exercises will be provided and discussed during the class.

As a leading example during the session, the concept of path dependency will be used to exemplify the different probabilistic notions. The idea is to give a direct application of a probabilistic view on a specific concept in social sciences.

An additional article is given to show the importance that have probabilities and predictions in current debates within the subfield of comparative politics.

More precisely, the following topics will be discussed. Notions related to probabilities:

- Events: random, simple and compounds
- Probability spaces, sample space
- independence and exclusiveness
- Joint, union and conditional probabilities

Notions related to random variables:

- Notions of random variables and distribution, realization and support
- Population and sample distributions
- Joint and marginal distributions
- Probability mass function and probability density function
  - location (mean and median), scale (standard deviation) and dispertion (variance) parameter
  - Expectation
- A focus on the normal distribution

Suggested reading

- Blyth, M. (2006). Great Punctuations: Prediction, Randomness, and the Evolution of Comparative Political Science. American Political Science Review, 100(4), 493-498. doi:10.1017/S0003055406062344

4th Session - Vectors and Matrices

This session aims to introduce to the basic notions of vectors and matrices. In a first part, some direct application of these notions are intoduced such as OLS, measurement theory (factor analysis) and network theory. Then, students will get familiar to basic notions and rules of matrices and operations on matrices. Direct example will be given.

- Why matrices and vectors matter in social sciences ?
  - practical example : theory of measurement, OLS, network theory
- Basic definition of scalar, vector and matrices : length and dimension
- Special matrices
- Operation with matrices and rules
- briefly introduce the transpose and the inverse of matrices

There are no readings for the fourth session

5th Session - Bonus

The last session will be mainly used as a wrap up session. It is the opportunity to take times to answer students' questions and developer further certain notions of interest in the audience.

There are no readings for the fifth session