Methods of Science & Mathematics Education Research: Statistics

Graduate Course, HBCSE, TIFR
2018-19 Semester I
Coordinator: Tathagata Sengupta

Tuesdays, 9 AM to 11 AM

Credits: 2

Objective of the course: To develop a hands-on understanding of statistical and probability theories, inferring statistical conclusions from raw data, and designing our own experiments and statistical models attempting to resolve challenges facing math and science education research.

Texts:
1. Agresti, A. & Finlay, B. *Statistical Methods for the Social Sciences*. Pearson International Edition.
2. Mulhern, G. & Greer, B. *Making sense of Data and Statistics in Psychology.* Palgrave.
3. Other texts/papers as the classroom discussion demands

Course structure:

The course will have three components:

Phase 1. *The theory of statistics and probability*
This is mainly where the above texts will be covered. Emphasis will be on beginning with problems, and arriving at the necessary theoretical frameworks and generalizations as demanded by such problems. We shall try to strike engaging classroom participation through active discussions.

Phase 2. *Making sense of data*
Once we have spent some time through the course, learning the basic tools and language of statistics, we will try out inferring 'mathematical and logical sense' out of some data available to us. What kind of data are we going to look at, and for what purpose, will be largely decided by the participants in the course, as the course progresses. For example, we could decide to look at available Government data related to Education, or data available with HBCSE from it's various engagements with educational projects over the years.

Though we begin the course with Phase 1, and Phase 2 sets in only after we have spent some time with Phase 1, these two phases will eventually overlap. We will need to revisit the theoretical frameworks, as and when necessary, as we start working with data analysis.

Phase 3. *Designing our own data experiments*
This will be the last phase of the course, where we design our own experiments, involving modeling an experiment, collecting data, analysing, and drawing inference. This would mostly be an 'out of the classroom' work, while we use the weekly classroom meetings mainly to discuss the challenges and the findings.

Contents (to be covered in Phase 1, ideally):

Week 1: *Preliminaries*
(measurement, concept of variables, sampling)

Week 2: *What kind of 'statistical meaning' can be derived from a given data?*
(measures of central tendencies, measures of variations, distributions, correlations and regressions)

Week 3,4: *How to use sample data to estimate parameter values for an entire population?*
(point estimation, interval estimation - confidence intervals, margin of error, effects of sample size, what goes wrong if we don't assume normal distribution for the population, Central Limit Theorem)

Week 5,6: *Testing of Hypotheses – Is a particular value for a parameter plausible?*
(forming hypotheses, test statistic, designing of data experiments, sampling, testing of hypotheses, significance tests, calculating and estimating errors)

Week 7: *How (and why) to compare two groups of data?*
(Independent and dependent variables, Bivariate analysis, Difference of estimates, Ratio of estimates, Standard error, Confidence intervals and significance tests for differences of estimates)

Week 8: *Comparisons continued: Whether and to what extent are two variables 'associated'?*
(Contingency tables, Chi-squared test of independence, Detecting patterns of association, Linear relationships, linear regression, least squares method, 'Outliers', Correlation, Estimating correlation)

Assessment:
Students taking this course for credit will be graded on the basis of assignments, and a term paper. All but one of the assignments (40%) will be periodic, based on the content covered in Phase 1. The last assignment will be on the Data Analysis work as part of Phase 2. The exact scheduling of the assignments will be done in consultation with the class. The term paper will be based on Phase 3, to be submitted at the end of the semester.