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Probability and statistics. A modular system of instruction at the University of J. E. Purkyně in Ústí nad Labem

Abstract. Probability and Statistics courses are offered at three colleges of the University of J.E. Purkyne in Usti nad Labem and at the Institute of Engineering Technology. These courses make part of the required curricula for several majors at different educational levels (baccalaureate, master's and engineering). Such wide range of coverage requires extensive personnel, technical and financial support. The Department of Mathematics utilized the Fund for Development of College Education in Czech Republic to develop a system of modular instruction for the courses of Probability and Statistics. This systems integrates requirements of individual majors with interests of all involved parties. At the same time, the system provides sufficient flexibility for all stakeholders to meet their specific needs and requirements.

Probability and Statistics courses are offered at three colleges of the University of J.E. Purkyně in Ústí nad Labem – College of Environmental Studies, College of Social and Economic Studies and College of Education. The colleges develop their own study programs and class curricula for specific majors program levels (baccalaureate, master's, engineering, full-time studies, distant studies, etc.), and student profiles. Elective statistics courses are offered in addition to compulsory courses of statistics for students who are not required to take statistics class in their study program, yet need basic knowledge of statistical analysis for their research projects and theses. Additionally, consultations for statistical data analysis are provided to university faculty involved in university and department research projects and studies. The University also offers statistical consultation services to the general public. Some colleges and departments also provide software for statistical data analysis.

It is evident that the University provides a wide spectrum of services which requires extensive personnel, technical, and financial support as well as central management. To facilitate the coordination of the whole project detailed analysis of needs and support capabilities of each college and department were

conducted. The information obtained was used to design a system of modular instruction for the courses of Probability and Statistics. This system integrates requirements of individual study majors with interests of all involved parties. At the same time, the system provides sufficient flexibility for all stakeholder to meet their specific needs and requirements, including application to other study programs and individual student profiles.

Compulsory statistics courses are most demanding with respect to faculty, technical and software support. Consequently, detailed analysis was focused on specific courses of study (majors), statistics requirements in individual years of study, unit requirements for lectures and seminars, and, mainly, the student profile for the specific major. One of the main objectives of this analysis was to examine whether the course and program requirements meet the needs of industries and services that hire the graduates and whether the graduates would be able to apply the acquired knowledge to "real world" problems. The next phase of the project was focused on analysis of teaching methods for offered statistics disciplines. Common and general terminology, definitions and methodology were collected and included into all statistics lectures as a common basis. Terms and phrases specific to individual disciplines were included into the curricula for statistics seminars (e.g., index statistical analysis, in-depth time series analysis, theory of coordinate estimation, etc.). In the modular system, the level of prior mathematical knowledge directly affects curricula for the different levels of the statistics courses. Consequently, in addition to the analysis of statistics disciplines, analysis of the curricula of mathematics disciplines was conducted for specific study programs and majors. Specifically, basic knowledge of high-school level mathematics is expected for students studying for humanity-subject teaching credentials and elementary level multiple-subject teaching credentials. A different level of mathematical attainment is also evident among teaching credentials for mathematics majors, engineer majors, and baccalaureate programs.

Similar analysis was also conducted for elective statistics courses and standard curricula were determined for the individual course lectures and seminars.

Specific consideration was given to the statistical needs of university faculty, the general public and students who cannot attend offered semester courses. To meet the needs of these groups, the system offers short-term intensive courses with a focus on the most used basic statistical methods. In addition, these courses are divided according to the specific statistical method presented or to the fields to which the participants need to apply statistics.

Based on these analyses, the following modular system of teaching statistics courses was proposed to the University. Each module is planned for one semester:

Module		Hours per Week		Course Valid.	
Code	Title	Lecture	Seminar	Credit	Exam.
$S1$	Introduction to Probability and Statistics	0	2	C	–
$S2$	Introduction to Probability	2	2	C	–
$S3$	Fundamentals of Statistical Methods	2	2	C	E
$S4$	Introduction to Mathematical Statistics	2	2	C	E

Table 1.

The following table presents a proposal of statistics requirements for specific student programs:

Master's Programs:	Compulsory Courses	Elective Courses
Elementary School Multiple–Subject Credential Program	$S1$	$S3$
Secondary/Middle School and High School Dual–Subject Credential Program (non–mathematical majors)	$S1$	$S3$
Secondary/Middle School Dual–Subject Credential Program (mathematical majors)	$S2$	$S3$[1]
High School Dual–Subject Credential Program (mathematical majors)	$S2$, $S4$	–
Five-year Engineering Program	$S2$, $S3$[1]	–
Baccalaureate Programs:		
Three-year Baccalaureate Programs at all three Colleges[2]	$S2$, $S3$[1]	–

Table 2.

The system is supplemented by short-term intensive courses as mentioned above. The table of contents for each module is listed in the attachments. Essential theoretical information is presented during lectures while seminars are

[1]Students can also choose course $S4$.

[2]College of Education, College of Social and Economic Studies and College of Environmental Studies.

designed to include extended and in-depth topics. The instruction of presented topics and statistical methods is oriented mainly towards the application of the knowledge in the education system and other professional fields. The students will practice applying the theoretical information in their seminar and yearly research projects. The instruction will also be adapted to accommodate the statistical software support available in the university computer network.

The goal of this curricula development was to unify and coordinate the instruction of statistics and thus increase the effectiveness of the instruction of this discipline on the individual university colleges. The modular system approach provided several valuable analyses including the needs of the instruction itself, needs of students who do not have compulsory statistics requirements, as well as needs of university faculty and others who need statistical methods for their research and professional projects and studies. The developed system is flexible enough to meet the requirements of all disciplines. It provides a differential extensive theoretical basis as well as opportunities to extend the knowledge by applying the acquired information in the practical fields of the individual disciplines. In addition, the course system considers the mathematical prerequisites of the participants. The modular system also allows students to broaden their theoretical knowledge of statistics through elective courses and specialized short-term intensive courses. The necessary prerequisite for creating this system was the availability of updated statistical software through the university computer network. This was essential especially for the course selection options at the individual colleges and for practical application of statistical methods. Today's professional fields require that graduates not only master the theoretical knowledge, but also be able to apply it through statistical software.

It is expected that the application of the modular system in the university study programs will decrease the personnel and financial requirements necessary for the instruction of statistics courses as well as improve the quality of the instruction. In the Czech Republic, new statistics requirements were included in the curricula for the Elementary School Multiple-Subject Teaching Credential Programs and curricula for other statistics courses at the University were edited.

ATTACHMENT:

*S*1 – INTRODUCTION TO PROBABILITY AND STATISTICS
Time requirements: 0/2 Credit

This course includes basic probability and statistics terminology, classic probability random space, calculating probability of random events, conditional probability and fundamental statistical terms. The emphasis is placed on measures of frequency, table and graphic depiction of data results, and measures of central tendency and variability. The use of computer programs in data analysis is included.

WEEKLY TOPICS

1. Random Event, Probability of Random Events;
2. Probability Formulas;
3. Conditional Probability;
4. Fundamental Statistical Terms;
5. Kinds of Statistical Reasoning;
6. One–dimensional Measures of Frequency of Statistical Variables;
7. Two–dimensional Measures of Frequency of Statistical Variables;
8. Graphic Depictions;
9. Moments;
10. Quantiles;
11. Measures of Central Tendency – Arithmetic Mean;
12. Measures of Central Tendency – Median, Mode;
13. Measures of Variability – Variance and Quartiles Distribution;
14. Measures of Variability – Range and Standard Deviation;
15. Time Reserve.

*S*2 – INTRODUCTION TO PROBABILITY

Time requirements: 2/2 Credit

Prerequisites: knowledge of linear algebra and mathematical analysis (calculus).

The course includes systematization of high school combinatorial analysis and probability, definitions of statistical computations for certain random events, application of the most important probability formulas, and basic simulation of random experiments and events. Mathematics and statistics computer programs are used.

WEEKLY TOPICS

1. Historical Background, Review of Combinatorial Analysis and Probability;
2. Induction and Recursion;
3. Basic Terms of the Combinatorial Analysis;
4. Types of Probability Random Spaces;
5. Axioms of Probability Random Space, Basic Laws of Probability;
6. Conditional Probability;
7. Types of Random Events;
8. Characteristics of Random Variables;
9. Relative Frequency Function;
10. Distribution of Discrete and Continuous Variables;
11. Binomial and Hypergeometric Distributions;
12. Poisson's Processes - Poisson and Exponential Distribution;
13. Normal Distribution;

14. Applications of Normal Distribution;
15. Central Limit Law of Probability.

*S*3 – FUNDAMENTALS OF STATISTICAL METHODS

Time requirements: 2/2 Credit, Examination
Prerequisites: *S*2 – Introduction to Probability

This course covers the most common statistical methods without emphasis on mathematical evidence of assertions. The emphasis is placed upon interval estimation, hypothesis testing, correlation, linear regression, and the use of computer programs in data analysis.

WEEKLY TOPICS

1. Random Selection of Sample;
2. Concepts of Probability Used in Statistics;
3. Measures of Central Tendency and Their Characteristics;
4. Measures of Variation and Their Characteristics;
5. Sample Selection from Normal Distribution;
6. Confidence Intervals for the Parameters of Normal Distribution;
7. Estimation of Confidence Intervals for the Parameters of Other Distributions;
8. Tests of Parameters from Normal Distribution;
9. Tests of Two Samples from Normal Distribution;
10. Estimation Tests of Parameters from Other Distributions;
11. Tests of Fit and Non-parametric Tests;
12. Tests of Independence in the Contingency Tables;
13. Linear Regression;
14. Correlation of Random Variables;
15. Time Series Analysis.

*S*4 – INTRODUCTION TO MATHEMATICAL STATISTICS

Time requirements: 2/2 Credit, Examination
Prerequisites: *S*2 – Introduction to Probability

This course covers methods for information transfer from a partial selection file to a master file. The methods of mathematical statistics emphasized in this course include point and interval estimation of basic distribution parameters, hypothesis testing of normal distribution parameters, estimation tests of other distribution parameters with one or two random samples, non-parametric tests, linear regression, and correlation of random variables.

WEEKLY TOPICS

1. Concepts of Probability Used in Statistics;
2. Basic Statistics;

3. Sample Selection from Normal Distribution;
4. Exponential Distributions;
5. Characteristics of Point Estimation – Maximal Plausibility and Credibility;
6. Characteristics of Point Estimation – Validity and Reliability;
7. Confidence Intervals – Intervals for Parameters from Basic Distributions;
8. Confidence Intervals – Estimated Intervals for Parameters from Basic Distributions;
9. Hypothesis Testing – Tests of Parameters from Basic Distributions;
10. Hypothesis Testing – Estimated Tests of Parameters from Basic Distributions;
11. Hypothesis Testing – Tests of Fit and Non–parametric Tests;
12. Linear Regression – Basic Model;
13. Linear Regression – Application;
14. Correlation of Random Variables;
15. Time Reserve.

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