Core Course Designation Proposal
Quantitative Reasoning

Faculty Name: Dr. Jay Pitocchelli, Dr. Lori LaPlante	**Department:** Biology
Course Number: BI 345	**Course Title:** Biostatistics
Initial Offering: Fall 2014	**Frequency course will be offered:** Each semester
Course Duration: One semester	**Maximum enrollment:** 20
Course Prerequisite(s): None	☒ **Course syllabus attached**

Course Description (as it appears in the College Catalogue)

An introduction to univariate statistics and the application and interpretation of statistical analyses in biological research. Sampling, experimental design, parametric and non-parametric techniques and the presentation of data are also covered. Assignments involve spreadsheet calculations and use of statistical software. Required for Biology and Environmental Science majors. Note: the number of enrolled Biology Department majors will be limited to 20 students per semester. This course satisfies the core requirement for quantitative reasoning.

Three hours of lecture each week for one semester. Four credits.

Goals and Objectives

Quantitative reasoning is defined as the capacity for creative problem solving through the ability to assess numerical evidence and to reason from data. Courses in quantitative reasoning will: promote understanding and appreciation of quantitative information and its application to problems from many areas; develop valid reasoning and decision-making skills; prepare students to apply numerical, logical, and analytical techniques as necessary to be active and responsible citizens, or as appropriate to the field; and develop in students the ability to gather, assess, and draw inferences from data and information, as well as the ability to recognize when an issue cannot be resolved using quantitative techniques.

Student Learning Outcomes

Please describe how the proposed course will fulfill each of the following student learning outcomes. For courses with multiple sections or instructors, describe the range of activities that would fulfill each student learning outcome.

Students who have completed their quantitative reasoning requirement should be able to:

1. Demonstrate a well-developed understanding of a theoretical and conceptual framework for quantitative reasoning, such as aspects of mathematics, statistics and logic

Students will develop a theoretical and conceptual framework for quantitative reasoning and statistical analyses that includes samples, populations, sampling techniques, exploratory data analysis (e.g., EDA: elementary statistics – Mean, SD, SE, CV), means testing (Student's t tests, ANOVA, post-hoc tests), relationships between variables (linear regression, correlation), frequency distributions (Chi Square) and non-parametric methods. These analyses incorporate a working knowledge of basic mathematical procedures: addition, subtraction, multiplication, division, various transformations (e.g., square, square root, reciprocal, log-natural, log10, arcsine,), etc. The materials for this course are presented in an organized progression from simpler (e.g., elementary statistics) to more complex analyses (e.g., correlation and regression) so students can gradually build a comprehensive repertoire of tools for scientific inquiry. Students will also learn how to use and interpret results from spreadsheet (Microsoft Excel) and statistical (SPSS) software.

Students will be able to demonstrate logic in two ways. First they will know how to solve problems using hypothetico-deductive reasoning, hypothesis testing and implementation of the scientific method. They will also demonstrate logic by successfully showing how they can discriminate among the different statistical procedures and recognizing when a specific research questions requires the proper application of a specific statistical analysis. These skills are examples of developing critical thinking that can be carried over to contemporary issues in their everyday life (see below).

2. Solve problems quantitatively using appropriate arithmetical, algebraic, or statistical methods

Students will learn a diverse set of univariate statistical analyses and their mathematical bases including exploratory data analysis (e.g., charts and graphs, elementary statistics – Mean, SD, etc.) means testing (Student's t tests, ANOVA, post-hoc tests), relationships (linear regression, correlation) and frequency distributions (Chi Square). Students will comprehend the logic and reasoning underlying the proper application of each statistical procedure. Through numerous examples in lecture and extensive work on problem sets, students will reinforce their understanding of the mathematical computations underlying the test, how to recognize when to use the appropriate statistical test, how to conduct the analysis using statistical software and how to interpret the results from this software (i.e., SPSS, Microsoft Excel).

3. Create and interpret visual representations of quantitative information, such as graphs or charts

Students learn the importance of graphical analyses through lectures where we discuss sample problems in their text and reinforce those examples with real studies from the scientific literature. They are exposed to the most common types of graphical analyses: scattergram, line charts, bar charts, addition of error bars, stacked graphs, pie charts, etc. Students realize the importance of constructing charts and graphs during the preliminary phase of statistical analysis referred to as exploratory data analysis or EDA. They recognize that scientist use graphical analysis to search for trends in the data and how it influences their choice of additional statistical analyses to answer their research question. Students are also able to understand the messages embedded in graphics and critically appraise the interpretation by its author(s). In terms of mechanics, students become fascile constructing their own charts and graphic representations of data (e.g.,) using Microsoft Excel and SPSS software.

4. Understand and critically assess data collection and its representation

Students will be able to recognize, compare and contrast the different types of data (nominal, ordinal, ratio, continuous, discrete, etc.) used in statistical analyses through lectures and examples from the scientific literature. Where possible, the professors will introduce data from their own research to further illustrate the importance of data/variable types, various methods for collecting data (automated versus by hand) and the careful attention paid to data collection.

Attention to detail, data collection and data entry into spreadsheets will be reinforced with problem sets and take home exams. These problem sets also include graphical representation of data (see above) and written summaries of the results of the analyses that demonstrate how the evidence relates to the research question posed by investigators at the beginning of the research.

5. Understand what can and cannot be inferred from a set of data and the limits of techniques used in order to recognize errors that can be made in carrying out analyses

Students will acquire knowledge about the rigorous requirements of statistical analysis that establish the validity of a researcher's findings and enable other scientists to critically appraise these results. Several important criteria used to evaluate statistical analyses are 1) the different types of parametric analyses and whether the type of data used are suitable for these analyses (e.g., Binomial, Poisson, Normal, F, Chi Square distributions), 2) the importance of the data meeting the statistical assumptions of parametric analyses (e.g., random sampling, data meet a normal distribution, homogeneity of variance, etc.), 3) proper use of data transformations (e.g, log, reciprocal, arc-sine, etc.), 4) non-parametric alternatives when statistical assumptions cannot be met (e.g., Mann-Whitney U, Wilcoxon's paired samples test, Spearman rank coefficient, Kendall's tau, etc.). Finally, the students will be able to judge whether the results provide the evidence that supports hypotheses and an author's conclusions about their research.

6. Communicate and present quantitative results effectively

The first step in communicating effectively is interpreting the results from statistical and spreadsheet software. Students will be proficient at understanding software output through exercises in the Weiler computer laboratory and their take home problem sets. Under supervision of the instructor, students will conduct exercises in the computer laboratory and learn how to interpret the results from Microsoft Excel and SPSS. Take home problems will provide additional outside of class opportunities for interpreting output from statistical or spreadsheet software.

The second step involves interpretation that connects the mathematics of the statistical analyses with the biological experimentation and question raised by the investigator. Students will confront the question – does the evidence from the statistical results support or reject the research hypotheses? The professor will demonstrate how to make these connections in lecture for each statistical test and students will have additional outside of class experiences with take home problems.

The third step is communicating the results. Written summaries of results are required for take home problems. The students are shown examples in lecture of the format scientists use to summarize their results in papers from the literature (e.g., several sentences and the important numerical results of the statistical analysis: $t=10.4$, one-tailed, $df = 12$, $p=0.005$). Students will interpret the results from their take home problem sets, make the connection with the biological questions raised by the researcher and write similar summaries.

7. Apply quantitative reasoning in a practical manner to everyday situations

In this course students learn about the scientific method and the role of statistics in scientific research. Learning the scientific method provides critical thinking skills, a connection between hypotheses, hypothesis testing and evidence that leads to support or rejection of hypotheses. Learning about statistics provides an understanding of the evidence that is largely based on mathematical or statistical analyses in scientific research.

These tools are easily carried over into everyday life. Students will encounter a problem, formulate hypotheses that could explain the problem, recognize mathematical evidence that could lead to support or rejection of their hypotheses, implement a plan to test these hypotheses, interpret the results and make decisions. A simple example would be purchasing airline tickets. Different companies claim to have the lowest prices. These claims are analogous to hypotheses. Testing hypotheses involves making a prediction that if Company A claims it has the lowest price (baggage, food, taxes, etc.), then a comprehensive study of all other airlines should show that Company A's prices are lower than the competition. A simple internet search would be equivalent to conducting the experiment and collecting data. Summing the fees and airline tickets for each carrier would be the mathematical analysis while comparing the totals would be the interpretation of the results. It is a very small leap to extend this metaphor to buying a house or mortgage, evaluating investment options for retirement, evaluating salary offers from potential employers, choosing a bank, buying a car, various forms of online shopping, etc.

Assessment

Please describe how course assignments or other measures in the proposed course will provide evidence of students' achievement of student learning outcomes.

The assessments are divided into lecture exams and take home assignments. There are three lecture exams – Exam 1, Exam 2, Final exam. Each exam is a combination of multiple choice and short answer questions. The exam questions are designed to assess the student's ability to comprehend the mechanics of each statistical test taught in the course.

1) null and alternate hypotheses
2) Formulae for calculating observed test statistics
3) Degrees of freedom based on sample size
4) Critical values and alpha levels
5) Interpretation of the observed test statistic versus critical value

There are theoretical questions about populations, samples and sampling. Students are asked to interpret graphs and charts. There are also questions about the proper implementation of a particular test where a student is given a hypothetical research situation and asked to identify which test is appropriate.

The take home exercises are problems that test the student's aptitude for selecting the appropriate statistical test, data entry, mathematical analysis of the data, interpretation of print outs from software and written summary of the results. It also assesses their capacity to manage electronic information and use computing technology.

☐ **Approved by department** ________________________________ __________

Signature of Department Chairperson Date

If applicable, please list name(s) of faculty experts outside your department that were consulted during the departmental review process.

☐ **Approved by committee of the core** ________________________________ __________

Signature of Committee Chairperson Date

Biostatistics BI 345

Biology Department, Saint Anselm College, Manchester, NH

Interactive Lecture Syllabus for Spring 2014

Dr. Jay Pitocchelli; Office 2316; ext. - 7397, e-mail - jpitocchATanselm.edu (remember to change the AT to @)

Home Page - **http://www.anselm.edu/homepage/jpitocch/welcome.html**

Office Hours: M, W 12:00 pm - 4:00 pm or by appointment

Biostatistical Analysis by Zar

Computer Software: Macintosh Operating System and StatView, SPSS.

Important Web Sites

Sakai

Grade Policy

BI 345 Homepage

CIS Portal

Week	Date	Topics	Chapters
		SECTION 1 - Introduction to Statistics	
1	13 JAN	Objectives Skills	1

		Course Introduction, History, Properties of data	
2	20 JAN	Hypothesis Testing, Freq. Distributions, Populations and Samples - Parameters, Stats	2
		SECTION 2 - Measures of Central Tendency and Variation	
3	27 JAN	Central Tendency - Mean, Median, Mode, Variance, SD, SE, Normal Distributions	3,4
4	3 FEB	Probability, Application of Normal Distribution - Z scores	6
5	10 FEB	Central Limit Theorem, Testing Sample Means	7-9
		SECTION 3 - Comparing Means and Distributions	
6	17 FEB	Confidence Limits , **Exam 1** on Wednesday, Takehome Exam 1 due on Wednesday	7-9
7	24 Feb	Comparisons of Means (2 samples) - Student's t test	7-9
8	3-9 MAR	**Mid-Semester Recess**	
9	10 MAR	Analysis of Variance (3 or more samples)	10-11
10	17 MAR	Multiple Comparisons	11
11	24 MAR	Multiple Comparisons Keys to understanding when to use means tests	11+Handouts
12	31 MAR	SECTION 4 - Relationships between Variables: Regression, Correlation, Chi Square	
12	31 MAR	**Exam 2 on Wednesday**, Linear Regression	17
13	7 APR	Linear Regression continued, Linear Correlation,	
		Easter Recess	
14	14 APR	Analysis of Frequencies, Goodness of Fit Keys to Understanding When to Use Relationships Tests	13
		SECTION 5 - Solutions to Data Problems: Transformations and Non-Parametric Analyses	
15	21 APR	Data Transformations, Special Medical Terms, Last day to do or turn in Extra Credit Assignments	22-23
16	28 APR	Non-parametric Stats	22-23
Exam Week	TBA	4:30 PM Final Exam is cumulative	

Disclaimer

All lecture and laboratory exercises and their dates are subject to change. Advance notification will be given in case of any changes.

Saint Anselm College Homepage

Dr. Jay's Homepage

Trademark and Disclaimers