EASTERN MICHIGAN UNIVERSITY
DIVISION OF ACADEMIC AFFAIRS

REQUEST FOR INCLUSION OF A COURSE IN THE GENERAL EDUCATION PROGRAM: EDUCATION FOR PARTICIPATION IN THE GLOBAL COMMUNITY

DEPARTMENT/SCHOOL: MATHEMATICS **COLLEGE:** ARTS AND SCIENCES

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1. Subject Code, Number, and Title: MATH 170 Elementary Statistics

2. Credit Hours three

3. Catalog description: An introduction to standard methods in statistics, emphasizing the rationale behind them and their application to problems in a variety of fields. Data summary and representation, measures of center and dispersion, correlation and regression, basic probability, point and interval estimation, and hypothesis testing.

4. This course is (check one):

   ☑ an existing course with no revisions (need not go through the input system)

   o an existing course with revisions (attach this form to Request for Course Revision form)

   o a new course (attach this form to Request for New Course form)

5. Check the General Education requirement this course is intended to meet. If the course is to be proposed for more than one requirement, submit a separate form for each one.

   o **Effective Communication**

   ☑ **Quantitative Reasoning (*QR designation*)**

   o **Writing Intensive (*WI designation*)**

   o **Perspectives on a Diverse World**

      o Global Awareness

      o U.S. Diversity

   o **Knowledge of the Disciplines**

      o Arts o Humanities

      o Science o Social Science

   o **Learning Beyond the Classroom (*LBC designation*)**

6. Rationale. Provide a concise, clear, jargon-free explanation of why this is a General Education course and how it fits into this specific requirement. This rationale should appear on the general course syllabus provided here and should be included in specific course syllabi given to students.

   Statistics can be applied to almost every other field of study. Learning statistics will give students a broad quantitative foundation for further study in specialized disciplines. This course will discuss in depth how quantitative information is generated, summarized, evaluated and interpreted, so that students will develop the habit of thinking clearly and critically about quantitative information in order to determine what information is reliable and which predictions can be trusted. For this reason, MATH 170 will count for the

Quantitative Reasoning requirement in the General Education program *Education for Participation in the Global Community*.

7. Clearly and concisely explain how this course meets each of the General Education outcomes for the requirement checked in number five (all outcomes should be addressed). To do this, (a) list the General Education outcomes for the requirement and explain how the course meets each outcome; and (b) explain, in general terms, the method(s) of evaluation to be used in the course and how these methods assess the degree to which students have met the General Education outcomes for this requirement.

Outcomes for quantitative reasoning:

Students will learn to solve real-life problems using a mathematical modeling process. They will learn to…

1. Identify an appropriate model.

a. Students will learn methods for analyzing quantitative questions that arise in the real world. Often these methods involve choosing an appropriate mathematical model for the situation. For example, they will learn how to tell whether the mean and standard deviation are appropriate summary measures of center and dispersion, or whether the median and quartiles would be more suited to the problem situation; what type of graphical representation might best be used for a given set of data; whether probability should be modeled in terms of equally likely outcomes, estimated empirically based on a long-run frequency model, or determined by some other process; whether a normal distribution is an appropriate model for an underlying distribution; how to come up with appropriate hypotheses in testable forms for applying the method of hypothesis testing.

b. On quizzes, tests, homeworks and projects, students will be asked questions which require them to make choices such as those outlined in (a).

2. Identify and discuss assumptions.

a. Nearly all statistical methods involve making assumptions. In choosing a suitable statistical approach, one would first consider a theoretical model of the data assumed under the null hypothesis; for instance, assume that the trait is normally distributed. Students will learn to identify and validate the model's assumptions (is some other distribution plausible?) through research and data analysis. Often model assumptions are best assured in the design phase of a statistical process. Students will learn to examine statistical design critically – were samples selected independently? Are they simple random samples or is a more sophisticated sampling process being used? Is the design consistent with the calculations and conclusions?

b. Students can be asked to discuss assumptions on quiz and test questions, and will be expected to list and perhaps justify assumptions in homework problems and in project writeups.

3. Collect or generate appropriate data.

a. Students will learn what data to collect and how to collect data. Specifically, through a variety of case studies and examples, students will learn to distinguish between experimental and observational studies; design a good research study; apply various random sampling techniques to reduce sampling bias; define clearly what is actually asked and measured in the study, for instance, distinguish between the sampled versus studied populations and define a measurable trait; identify different types of measurements (for instance, numerical and categorical) associated with different data analysis techniques; and relate the size of the sample to the reliability of the statistical inferences.

b. Quiz, test and homework problems will test students' knowledge of data collection techniques and the issues surrounding them; and actual data collection can be part of a project.

4. Analyze a situation using arithmetic, geometric, algebraic, and probabilistic or statistical methods.

a. Students will learn to: simulate an event and approximate the probability of it happening using technology (graphing calculators, spreadsheet or statistical software); recognize appropriate and inappropriate application of statistical methods through the discussion of statistics presented in a

journal or newspaper article; recognize both valid and misleading uses of statistics to support an argument; and perform both descriptive and inferential data analyses on data sets from real-life situations using technology. Students produce and analyze data summaries such as frequency, cumulative frequency and relative frequency tables; graphical summaries such as pie charts, bar charts, histograms, stem-and-leaf plots, and box plots; measures of location such as mean, median, quartiles and other percentiles; measures of spread such as standard deviation, interquartile range, and interdecile range; scatter plots, trend lines or curves, and residual plots; standard sample-based point and interval estimates for population parameters such as polling estimates for the percentage of voters who support a candidate, or estimates of the difference in the effect of two different treatments in a medical study; test hypotheses by calculating the value of a test statistic and comparing it to a critical value from a model probability distribution. Algebra is interwoven through fundamental formulas for data summaries. The connections and interplay between arithmetic, algebraic and graphical tools is emphasized; for example, students understand the effect of converting from one unit of measure to another (such as inches to centimeters) on data summaries and plots and can see from the formulas why these effects occur.

b. Virtually every quiz, test and homework question will involve one or more of these types of methods. The connections will be tested by all these means with multi-part questions in which students use analyze the same data with different tools and then compare and contrast the results.

5. Estimate answers.

a. Although "Estimation" is a standard topic in inferential statistics, estimating answers is a much more basic and pervasive quantitative skill that is not relegated to this one portion of the course. In any quantitative setting it is important to develop the habit and skill of estimating answers to cultivate conceptual understanding of the tools and results and as a guard against blind acceptance of results that may be in error. This kind of informal estimation is also good conceptual preparation for the introduction of formal estimation procedures. It accustoms students to the idea that approximate answers may be perfectly acceptable, and that the standard for how close an estimate must be to the true value in order to be acceptable depends on how the answer will be used. Both qualitative (is a quality inspector more likely, less likely, or equally likely to randomly select 3 defective parts from a lot of 10, or 30 defectives from a lot of 100 if 20% of the items in the lot are defective?) and quantitative (approximately how large a sample would be needed to estimate the true proportion of defectives in a large lot?) estimates will be elicited and compared to the results of experiments, simulations and calculations as statistical tools are developed.

b. This type of estimation will be a central part of class discussions and will be the initial step in discussion problems on quizzes and tests; it will be used in conjunction with a follow up asking students to discuss the correctness and quality of their estimates.

6. Propose and evaluate solutions.

a. One of the major lessons that students need to learn is that a problem is not done when a solution is produced. It is always important to check the result for consistency with other knowledge and with other approaches. For example, if two data sets are compared using histograms, it is important to see whether or not similarities persist if data are grouped into different intervals. A pair of variables may have a strong but non-linear relationship that is not apparent from their correlation – checking the scatter plot can clarify it. A statistical experiment may fail to find a difference in two treatments if the samples are small (suggesting either a larger study or reassessing the researcher's hypothesis), or may, through large samples, detect a real difference that has no practical importance. Students need to develop the habit of checking each solution for internal and external consistency.

b. The skill can be assessed through multi-part questions on quizzes and tests. The habit can be encouraged by gradually making this final step an expected part of the answer to any question – without prompting - and a crucial part of any project.

7. Predict outcomes in other situations based on what they have learned from their analysis.

a. Students will learn to use inductive reasoning carefully to make predictions or draw general conclusion from the specific information gathered from their analysis that will apply in other situations. At the same time, they will learn to avoid over-generalization, making the statement too broad in scope, and to avoid stating the prediction in an assertive tone (that is, avoid words such as always, must, definitely etc.) They will learn that the design of a statistical experiment is critical to the generalizability of its results
b. This outcome can best be tested for on homework problems and in projects.

8. Understand and communicate quantitative relationships using symbols, equations, graphs, and tables.

a. These skills are developed throughout the course. For example, in studying descriptive statistics students learn to select and produce appropriate tables and charts (graphs) to translate raw data into useful information; they learn to use to standard symbols for important data measures such as the mean and standard deviation, and to apply the formulas that give succinct instructions for calculating these measures. When studying regression they learn to produce scatter plots with appropriate titles, axis labels and units, and produce tables comparing observed to predicted values. In inferential statistics, where the core idea is generalizing from a sample to a population, students learn the notational conventions that distinguish between population and sample measures. They represent confidence intervals on a number line, and apply tests to data given typically in a table.
b. Each of these ways of communicating a quantitative relationship will be explicitly asked for in quiz, test and homework questions, and in the write-ups of projects.

9. Share their findings in oral and written reports using appropriate mathematical language.

a. See b.
b. Students will be asked to write a report and/or give an oral report on the analysis of a dataset from a mini-project/case study. Students will be given advice and feedback on data visualization and presentation. The report is graded on the validity of the data analysis and also on the organization and clarity of the report, which should be understandable to a layman.

10. Write summaries to explain how they reached their conclusions.

a. See b.
b. As part of a project, students will be asked to write a carefully organized, clear and accurate summary for the mini-project/case study. They should describe precisely the models used, any rationale developed to implement these models, the methods used to analyze these data assumptions, and so on. They should explain why the methods are appropriate to reach the conclusions; and they should back up the conclusion with references to the analysis results, graphs, tables, etc.

11. Draw inferences from a model.

a. The second half of the course focuses almost entirely on statistical inference. Students will learn when it is valid to draw inferences from a study, and what it really means to so. The inferences drawn from any study depend crucially on the study design. Students will learn to distinguish two distinct forms of inference – causal inference and inference to the population as a whole. They will recognize that the statistical inference of cause-and-effect relationships can be drawn from randomized experiments, but not from observational studies; and that inferences to population can be drawn from random sampling studies, but not otherwise.
b. Virtually all quiz, test and homework problems in the second half of the course will deal with statistical inference. Students will be asked repeatedly about what inferences are valid, and why, and what it really means.

12. Discuss the limitations of the model.

a. Throughout the second half of the course, it will be repeatedly stressed that there are limitations to any statistical study. As a simple example, consider a sample survey. Construction of confidence intervals is based on the assumption that the sample is a simple random sample, something that is actually very difficult to achieve; and the confidence interval itself comes with a degree of certainty, meaning that it is quite possible for the parameter to outside the confidence interval even if the sample is truly random. In fact, if you look at a large number of different survey samples, it is very likely that for some of

them, the parameter *will* be outside the confidence interval. These ideas will be stressed, and students will always be required to check that various conditions are present before applying a particular statistical technique.

b. This outcome will be tested for in quiz and test questions and in homework problems; and in projects it will be expected that students indicate their understanding of the limitations of the analysis they have just provided. They will be asked to: discuss the validity and scope of the analyses and models from a mini-project/case study; describe the scientific and statistical issues raised by the results; discuss limitations in data, scientific background and statistical expertise; and also to make suggestions for further analysis or future directions, such as how the experiment might be modified to accomplish another objective.

8. Attach a syllabus (1-inch margins and 10-12 pt. font). The syllabus must include the rationale from #6 above and clearly reflect the outcomes and methods detailed in #7 above.

MATH 170 ELEMENTARY STATISTICS

Course Catalog Description:
An introduction to standard methods in statistics, emphasizing the rationale behind them and their application to problems in a variety of fields. Data summary and representation, measures of center and dispersion, correlation and regression, basic probability, point and interval estimation, and hypothesis testing.

General Education
Statistics can be applied to almost every other field of study. Learning statistics will give students a broad quantitative foundation for further study in specialized disciplines. This course will discuss in depth how quantitative information is generated, summarized, evaluated and interpreted, so that students will develop the habit of thinking clearly and critically about quantitative information in order to determine what information is reliable and which predictions can be trusted. For this reason, MATH 170 will count for the **Quantitative Reasoning** requirement in the General Education program *Education for Participation in the Global Community*.

Goal of the Course
The goal of the course is to prepare students to

- Review and evaluate quantitative information in real-world applications.
- Perform basic analysis of data in a variety of fields.
- Present statistical analyses to audiences with diverse levels of statistical understanding.
- Pursue subsequent study of advanced statistical methods.

Course Objectives
Upon completing the course, students should be able to:

- Formulate research questions that arise in the real world.
- State the hypothesis/objective precisely.
- Design a good research study and apply various random sampling techniques to reduce sampling bias.
- Identify different types of measurements (for instance, numerical, categorical etc.) associated with different data analysis techniques.
- Simulate an event using technology and approximate the probability of it happening.
- Perform both descriptive and inferential data analyses on data sets from real-life situations using technology.
- Identify and validate the model assumptions through information research and data analysis.
- Quantify the likely size of sampling error with a so-called confidence interval approach for estimation.
- Use a p-value approach (a type of argument by contradiction) to make a plausible argument/guess about the truth of a hypothesis, in the situation of testing hypotheses.
- Examine the distribution of individual variables graphically and analytically.

- Describe a relationship between two variables with either a simple regression model or a two-way table, analytically using statistics such as the correlation coefficient or a goodness-of-fit test. Also, visualize the relationship graphically using scatter plots.
- Use both graphical methods (side-by-side box plot/histogram) and analytical methods (test statistics) to facilitate the comparisons between two groups, in the case of comparative studies.
- Share their findings in oral and/or written reports
- Use inductive reasoning carefully to make predictions and draw general conclusions in other situations from the specific information gathered from their analysis. Know the limitations of inferences from models.

Textbook (Recommended, however, may vary by instructor)
"Just the Essentials of Elementary Statistics", 9th edition, Johnson & Kuby, published by Brooks/Cole. Chapter 1 to Chapter 10.

Attendance and Class Participation
Reading the textbook in advance is highly recommended. You'll find that reading the material before class will greatly assist you in participating in the lesson presented in class.

Homework and Projects
Expect regular homework assignments. The homework consists of computational and data-analysis problems from the textbook. For the data-analysis problems, you need to analyze a data set and write a brief report to summarize the results of the analysis. The report should be neatly written (typed preferably) and should contain a) a statement of the problem, b) results of analysis, c) discussion and d) conclusion. Specifically, the report should

- Describe precisely the models used, any rationale developed to implement these models, the methods used to analyze these data assumptions, and so on.
- Explain why the methods are appropriate to reach the conclusions.
- Back up the conclusion with references to the analysis results, graphs, tables, etc.
- Discuss the limitations of the model and how the results could be improved.

Technology
Technology will be integrated throughout the course as a tool for data analysis.

Assessment
Course assessment will include quizzes, tests, group/individual projects, presentations, and in-class activities.

Course Outline
1. Statistics.
    What Is Statistics?
    Introduction to Basic Terms.
    Measurability and Variability.
    Data Collection.
    Comparison of Probability and Statistics.
    Statistics and Technology.
2. Descriptive Analysis and Presentation of Single-Variable Data.
    Graphic Presentation of Data.
    Graphs, Pareto Diagrams, and Stem-and-Leaf Displays.
    Frequency Distributions and Histograms.
    Numerical Descriptive Statistics.
    Measures of Central Tendency.
    Measures of Dispersion.
    Mean and Standard Deviation of Frequency Distribution.
    Measures of Position.
    Interpreting and Understanding Standard Deviation.
    The Art of Statistical Deception.
3. Descriptive Analysis and Presentation of Bivariate Data.

Bivariate Data.
Linear Correlation.
Linear Regression.

4. Probability.
   - Concepts of Probability.
   - The Nature of Probability.
   - Probability of Events.
   - Simple Sample Spaces.
   - Rules of Probability.
   - Calculating Probabilities of Compound Events.
   - Mutually Exclusive Events and the Addition Rule.
   - Independence, the Multiplication Rule, and Conditional Probability.
   - Combining the Rules of Probability.
5. Probability Distributions (Discrete Variables).
   - Random Variables.
   - Probability Distributions of a Discrete Random Variable.
   - Mean and Variance of a Discrete Probability Distribution.
   - The Binomial Probability Distribution.
   - Mean and Standard Deviation of the Binomial Distribution.
6. Normal Probability Distributions.
   - Normal Probability Distributions.
   - The Standard Normal Distributions.
   - Applications of Normal Distributions.
   - Normal Approximation of the Binomial.
7. Sample Variability.
   - Sampling Distributions.
   - The Sampling Distribution of Sample Means.
   - Application of the Sampling Distribution of Sample Means.
8. Introduction to Statistical Inferences.
   - The Nature of Estimation.
   - Estimation of Mean μ (s Known).
   - The Nature of Hypothesis Testing.
   - Hypothesis Test of Mean μ (s Known): A Probability-Value Approach.
   - Hypothesis Test of Mean μ (s Known): A Classical Approach.
9. Inferences Involving One Population.
   - Inferences About Mean μ (s Unknown).
   - Inferences About the Binomial Probability of Success.
   - Inferences About the Variance and Standard Deviation.
10. Inferences Involving Two Populations.
    - Dependent and Independent Samples.
    - Inferences Concerning the Mean Difference Using Two Dependent Samples.
    - Inferences Concerning the Difference Between Means Using Two Independent Samples.
    - Inferences Concerning the Difference Between Proportions Using Two Independent Samples.
    - Inferences Concerning the Ratio of Variances Using Two Independent Samples.

Please submit all materials in electronic form.

Action of the Department/College

1.

Department

Vote of department faculty: For **11** Against **0** Abstentions **5**

_____ _____
Department Head Date

2.

College

_____ _____
College Dean Date

Action of General Education Advisory Committee

Vote of General Education Committee: For _____Against _____ Abstentions _____

_____ _____
Chairperson, General Education Advisory Committee Date

Approval

_____ _____
Associate Vice-President for Undergraduate Studies and Curriculum Date