Judges' Comments on the 10-12 Project Competition

Selecting a question:

Selecting a good question for a statistics project is important. Not only should the question be interesting, but it also should give rise to data that lend themselves to statistical treatment. For example, if the question leads to a categorical response (i.e., What is your favorite color?), one may be left with nothing more than a few counts (one for each category of color). This limits both the graphical and statistical analyses that can be used. Be sure the question can be answered with the data collected. Questions need to be clearly stated. If more than one question is posed, each should be answered. Finally, upon completion of the project, it should be reviewed to be certain the question posed is actually answered.

Collecting data:

Collecting data properly is challenging. Students who find data sets that have already been compiled often do not realize the pitfalls and potential errors of data collection. As a consequence, they miss an opportunity to understand this vital phase. For this reason, the scoring rubric emphasizes data collection by the students, and projects in which students collect data from scratch are viewed more highly than those in which students utilize existing data. Good data collection is an extremely important portion of the project.

The data collection process should be described clearly and the student's role in its collection should be clear. The variables in the study should be defined clearly in terms of what is to be measured and how. If a random sample is taken, the randomization process should be given. Haphazard or other unplanned sampling is not random sampling and can lead to biased results.

Replication is important in any study. For example, the purpose of a study may be to compare the growth of corn plants with and without fertilizer. Suppose two pots are used and two corn seeds are planted in each pot. Then it is determined randomly which pot gets which treatment (fertilizer or no fertilizer). Even though there are two plants under each treatment, there is no replication. The reason for this is treatments were assigned randomly to pots (not plants). More than one pot would have to be used for each treatment for there to be true replication.

If a survey is conducted a copy of the survey should be included in the project as an appendix. For all projects, raw data should be included as an appendix.

When fellow students are used in a survey, each participant should randomly receive a student identification number and only the student identification number should be linked to the responses. The student participants' names should never appear in the project paper.

Graphs:

Graphical displays provide insight into data. Many projects fail to take advantage of this important statistical tool. In projects using at least one graphical display, the graphs are often only the most rudimentary pie charts. Stem-and-leaf, dot plots, box plots, and scatter plots may provide more insight into the data. Displaying sample means with error bars also may be helpful. Care should be taken to use appropriate graphs. For instance if you are comparing a quantitative variable from different groups, boxplots are appropriate. If you are comparing

two quantitative variables, a scatterplot is appropriate. If you are only exploring one variable(for example, favorite color), a bar chart is better than a scatterplot or line plot. Replication permits variability to be captured by the data; appropriate graphs make it visible.

Inference:

When a sample is drawn, inferential statistics usually are needed to answer a question. While useful, graphs and descriptive statistics alone are not sufficient in this instance. At this level, only projects with some level of formal inference are competitive.

When using formal inferential statistical tests, the assumptions for any method should be checked. For example, variances should not be pooled if they are substantially different (which can be tested) and the sample sizes are reasonably large. Students should fully understand the methods they use. It is better to use simpler (but appropriate) methods correctly than to apply more sophisticated procedures improperly. Below are a few notes about common tests and procedures used in the competition.

For hypothesis tests, care should be taken to state the null and alternative hypotheses appropriately. Remember that in a subject-matter area, the hypothesis is what the researcher wants to prove. In statistics, this usually becomes the alternative hypothesis, as the strongest conclusions can be drawn from rejecting the null in favor of the alternative. Note the null hypothesis is never 'accepted.' Instead, it is traditional to say "we failed to reject the null hypothesis," which gives the proper impression that it is not known with certainty that the null is true but that the data does not refute it. The reason for this is the probability of a type II error is not known.

In the case of confidence intervals, care should be taken to make sure that they are interpreted correctly. Confidence intervals estimate population parameters, not sample statistics. Additionally, a confidence interval cannot confirm a test statistic.

For simple linear regression inference, note that r^2 represents the amount of *variability* in the response variable explained (removed) by the explanatory variable, not the fraction of the response variable explained.

Additionally, remember that if data are collected on all members in the population, a census is taken. Because inferential methods are used to draw conclusions about the population based on the sample, these methods are inappropriate if all population values have been observed. However, some thought should be given to whether a census actually was achieved. If the goal was to survey everyone in a school, some students may be absent or refuse to respond.

Presentation:

The project font size should be at least 12 pt, and complete sentences and standard grammar should be used. This is a formal paper so the use of “I”, and “we” should be avoided. Only words of a professional nature should be used. The writing emphasis should be on the statistical aspects of the study. Background information should lead to a precise statement of the question to be considered. Some projects benefit from a more detailed description of the data collection phase. Details of the statistical analysis should be presented. The statistical methods should be outlined and discussed clearly. The analysis should serve as the foundation for any conclusions drawn.

A "reflection on the process" should be a realistic self-evaluation of the work. Simply stating that “all went well” raises concerns, as few studies ever have everything go right. The reflection portion of the paper should also address areas of further research.