THE BENEFITS OF FITTING THE STATISTICAL POSTER COMPETITION INTO THE CURRICULUM

Linda M. Quinn
QED Industries, Inc.
USA

Recognizing that there is a continuing need to encourage and promote the understanding and application of statistics, the American Statistical Association sponsors a statistical poster competition for grades K-12 that allows students to discover and express their creativity in the analysis of data occurring in their everyday lives. A statistical poster is a visual display containing two or more related graphics that summarize a set of data, that look at the data from different points of view, and that answer some specific questions about the data. If we focus on the mechanical aspects of collecting data and rote learning of how to choose and draw an appropriate graph to summarize it, we still have indeed added another time-consuming activity to the crowded curriculum. In the classroom, graphing activities for poster competitions can be integrated learning activities that can enhance the curriculum rather than burden it.

INTRODUCTION

Society has become more and more dependent on statistics and other numerical information. However, all this information is meaningless if it cannot be presented in a proper and easily accessible way. Charts and maps are effective aids to those who need to illustrate numerical data. Charts can highlight the important points in a mass of data and illustrate complicated relationships and produce clarity. At the same time, it is difficult to create good charts.

Recognizing that there is a continuing need to encourage and promote the understanding and application of statistics, the American Statistical Association (ASA) and the National Council of Teachers of Mathematics (NCTM) sponsor a statistical poster competition for grades K-12 that allow students to discover and express their creativity in the analysis of data occurring in their everyday lives. We are bombarded with statistical information on television and in the newspapers, and with the increasing use of computers the use of statistics and graphics in particular is likely to increase.

But where do graphics and statistical posters fit in the classroom, in an already crowded curriculum? Certainly the need cannot be ignored. A statistical poster is a visual display containing two or more related graphics (plots, charts, maps, etc.) that summarize a set of data, that look at the data from different points of view, and that answer some specific questions about the data. As reflected in the definition of a statistical poster, one purpose of graphs is data presentation. However, if we focus on the mechanical aspects of collecting data and rote learning of how to choose and draw an appropriate graph to summarize it, we still have indeed added another time-consuming activity to the crowded curriculum. Further, this type of activity will not provide students with the ability to use graphs for problem solving or even to critically analyze graphics in newspapers, on television, or in their textbooks.

In the classroom, graphs and activities involving graphs can be much more. Students are deeply interested in investigating. They love to collect data, especially on themselves. The discussions and decisions involving the collection and classification of data can lead to rich discussions on the meaning and appropriate interpretation of the data. The NCTM *Standards 2000* presents the vision that problem solving is the main goal of mathematics instruction at all levels (National Council of Teachers of Mathematics, 2000). It calls for student involvement in statistical activities at all grade levels and indicates that statistical thinking should start in the primary grades with the creation of student data from class activities and surveys on topics of student interest. For the higher grades, the guidelines suggest that the emphasis should be on collecting, organizing, summarizing, and interpreting data from other school disciplines such as the physical or the social sciences, as well as the outside interests of the students.

The discussion and decisions involved in creating graphics of the data should ensure that the students spend as much time deriving meaning from the data as they did collecting and graphing it. If the data are related to study in other subject areas, then the data-handling activities will be useful tools for building the problem solving and presentation skills of the students that will also enrich their learning of the other disciplines. The mechanics of drawing the graphs are less important than the reasoning and interpretation demonstrated by the student. Judging places more emphasis on the impact of the display, the clarity of its message, and, the appropriateness of the graphics than on the perfection the drawing reflects.

INTERDISCIPLINARY NATURE

The curriculum in statistics should emphasize the collection, organization, display, and interpretation of real data from many sources. Students should be encouraged to collect their own data in accordance with their interests. Other disciplines being studied by students offer excellent sources of data. Social science and geography courses use data on social characteristics, demographics and economics. Laboratory science courses provide excellent opportunities for students to collect data and understand sources of variation. Language and literature classes can offer students the ability to determine literary interests. Students will learn to be more alert to the interesting data sets frequently occurring in daily life.

"Who Died in America's Wars?" a poster entered into the 1998 competition was developed by a twelfth grader from coursework in American and World history. The student presented data on each branch of the military for all wars. The graphs incorporated information on the length of the war, the enlistment versus death rate by military branch, and the changes over the decades.

In 1995 the British Medical Journal published a paper entitled *Why Do Old Men have Big Ears?* (Heathcote, 1995). This paper captured the interest of middle school students looking for a topic for their poster projects. After considering the paper and its results, the students came up with additional questions that were not considered. This became the basis for their winning poster entry in 1996. They wrote up their experience, including their continuing interest in the project in a *Stats* article (Young, Young, Kelly, Kirby, & Kelly, 1999).

THE SCIENTIFIC METHOD

The scientific method, simply put, is nothing more than (a) a focused question, (b) collecting appropriate data, (c) analyzing the data intelligently, and (d) drawing the correct conclusions. Graphics are an easy and entertaining method for teaching students the scientific method, showing them that by attacking problems scientifically they can tackle any problem. Understanding graphics will provide them with a method for attacking problems in other disciplines and encourage them to believe that they can critically analyze data by examining it scientifically.

Students always have questions. The bigger issue is to develop a focused question. Consider keeping a running list of questions that come up in the course of a week that could be answered by collecting data and presenting a graph. Some of the questions may be related to the subject material being presented, and others may be a result of student brainstorming to identify poster topics. At this stage, you do not want to worry about how feasible it would be to collect the data or how you would collect the data. This should give a large list of potential questions.

Next, start evaluating the questions to try and focus the question. Define terms that are in the question. Pereira-Mendoza (1995) describes an activity involving the collection of data on the pets of seven-year-old students. The starting point for the activity is the question "What pets do the students have?" To answer the question the students have to wrestle with their definition of a pet—is a tank of fish one pet or many—and the implications of the definition on how the graph will look. If each fish is a pet, then fish are the most popular pet; if each fish tank is considered one pet, then dogs are the most popular. It is through this type of exploration that the students start to understand that the visual impact of a graph can depend on how they define the terms. Thus, perhaps even in the primary grades, we can sow the seeds for learning how to critically analyze statistics and graphs.

For the poster competition, it is important for the students to look at several related questions within their question of interest. This begins the exploration of looking at multi-faceted data. Depending on the grade level, you can introduce the idea of a cause and effect diagram to enable the students to identify other questions that are related, or to identify other groups of data to collect.

Of course the discussion of the question begins to intertwine with the data collection methods. Now is the time to evaluate the feasibility of obtaining the desired data. There are several sources of data for the students to explore, some allowing the student to be more active in the process than others. The best presentations of data, and the best posters, will likely be those where the data are meaningful to the students and where the students have collected the data themselves—whether by survey or experimentation or by obtaining the data from published sources to address some question of interest to them.

Using published research allows the student to develop research skills as well as understand how useful the Internet can be in finding information. Survey, observation, and experimentation involve more time investment by the student. Once again, this data collection effort could be combined with other class projects, including science fair projects. It is at this stage that students may be able to begin the discussion of the advantages and disadvantages of the different data collection techniques. They also can begin to challenge how data presented in the newspapers and news reports were collected and how it impacts what conclusions can be drawn. It is also in these discussions that the impact of variation becomes important, particularly as you discuss standardizing the data collection.

As with any research, the time used to develop questions for surveys, or an experimental protocol will determine how easily the data will be analyzed and how acceptable the conclusions will be. Issues of sample size can be discussed and their impact on the presentation and acceptance of your conclusions.

Finally, you will use graphics to display your information. As you are creating your graphs, keep in mind that the reader of your poster should be able to look at the graphs and understand the story of the data. The reader should be able to immediately ascertain your research question and your conclusions, without having to read any description on the research. It may be useful to think of graphs as photos that make it easy for your reader to visualize all of the information that you have collected.

In trying to select an appropriate graph or graphs to represent your data, perhaps a brief review of the kinds of data might be helpful. Broadly, data fall into two major categories: qualitative data (e.g., words or text) and quantitative data (numbers). Quantitative data can be further broken down into whether the variable is discrete (it takes on only certain values in a range of numbers) or continuous (it takes on all values in a range of numbers). Bar graphs and pie charts are more appropriate graphs for displaying qualitative variables or discrete quantitative variables. Graphs such as histograms and stem-and-leaf plots are more appropriate for displaying continuous quantitative variables or numerical values that have been grouped together.

Further, not only can the students be shown that there may be alternative representations of the same aspect of the data, but that different aspects of the same data may also allow different representations. This draws us right into the discussion about how to draw conclusions from graphs. Remember that your reader is not as familiar with your project and data as are you. You should strive to make your graphs as "user-friendly" as possible. As a check, have a friend or family member who is unfamiliar with your data look at the graph and describe what the graph represents to him or her. This will give you an indication of how clear your graph is in portraying your data. A graph should contain an accurate and descriptive title as well as descriptive labels for the axes.

Now that we have made sure that each graph is focused on the central question, let us discuss some features of an effective graph. Effective graphs draw the reader's attention. They sell the poster to the reader. The use of color, catchy titles, unique graphical components, etc., adds to the visual appeal of the poster. If you can get the reader of the poster to interact with the poster it is a big plus.

The overall placement of materials on the poster is important. Surely, we can all agree that there should be a logical placement of the components of the poster such that the reader can comprehend the intellectual path leading to the conclusions. The placement of the components should enhance not interfere with the message contained within the poster.

Lastly, be creative. The more uniquely you represent the information; the more likely the poster will draw the reader's attention. Ask yourself the question: "How can I make this more appealing to someone who is not familiar with my data?" Or better yet, ask a friend, family member, or schoolmate to describe what the poster says to them. Oftentimes you will find that what seemed obvious to you is not at all obvious to someone who is not familiar with your topic. Usually, if you can get a parent to understand what the poster is about, then you are in pretty good shape.

THE POSTER JUDGING RUBRIC

Posters have always been judged with several criteria in mind: overall impact of the display, clarity of the message, appropriateness of the graphics, and creativity. Up until last year judging has typically involved an iterative process of eliminating non-winners until there is a small subset of posters that could be judged for placement awards. The judges (as many as twelve) then discuss the merits of the potential winning entries using the criteria above. Judges then rank the remaining entries, and posters are placed based on average rankings.

This method of judging has given rise to several issues. Rankings were sometimes drastically different from regional rankings for posters that had advanced for national consideration. Posters with glaring errors, including statistical errors, were sometimes chosen as winners. Often times, there was complete disagreement in the ranking of posters, and winners were placed based on averages of very disparate rankings.

The Michigan regional competition started using a judging rubric in 2000 during their first competition. The national competition used a modified version of it in 2001 and encouraged other regional competitions to use it as well. The rubric has five factors: overall impact of the display, technical aspects, clarity of the message, appropriateness of the graphics, and creativity. Each factor is graded on a scale from one to five. Overall impact considers the use of space, the dimensions of the research topic, the overall readability and neatness as well as the poster design aspects. The technical aspects factor assesses spelling, grammar, and the use of colors or patterns. The clarity of the message evaluates how well the poster tells a story. Appropriateness of the graphics deals with the statistical appropriateness of the graphs. Creativity evaluates the data collection methods, the sample size issues, and the “who cares element.”

The top ten posters in each grade category were sent by each regional competition to the national judging. This eliminated the need to search through posters to find the potential winners. Posters were evaluated using the judging rubric. Statisticians and math teachers serve as judges for the competition. Winning posters tended to receive top marks in all five categories. Judges then discussed the posters and ranked them for the final awards.

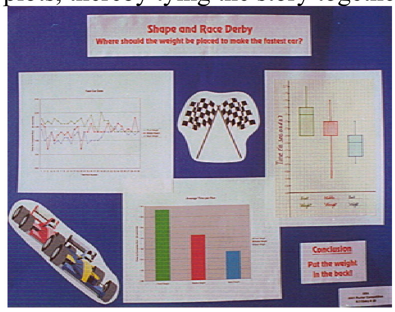
There were some issues with the rubric used. Statisticians were bothered by the fact that a poster could score poorly on the statistical appropriateness and still score at an overall score of 18+ out of 25. There is still disagreement of assigning ratings within factors. Also, there are some crossover effects between factors. For example, the clarity of the message is certainly lost when neatness, readability, and statistical correctness are lacking.

Overall, the judges felt that the rubric worked well in the poster judging. All judges felt that the posters that placed in the competition were the best. Secondly, there was more consistency amongst the judges as to the final rankings of the winning entries, since the discussions of merit were framed within the five factors used for judging. Lastly, the judges felt that the rubric would serve as a good development tool for teachers working with students as they create their posters.

2001 FIRST PLACE WINNERS, Center for Statistical Education (1992)

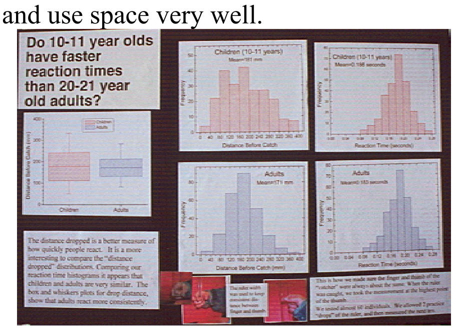
Grade category K-3:

This poster shows how to weight a derby car to get the fastest race times. The box plot shows the distribution of race times for each of the three weight positions. The bar chart shows the average race time for each condition. The line plot shows race times over the course of each successive time trial. Notice that the same color is used to represent the front position in all three plots, thereby tying the story together.



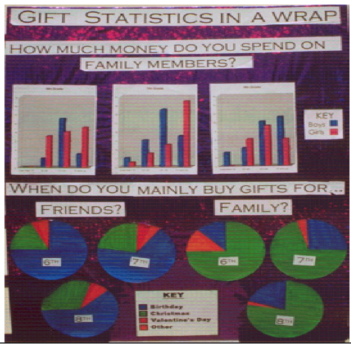
Grade category 4-6:

This poster shows the results of an experiment on reaction times studying both children and adults. The histograms are aligned so that comparisons can be made directly. Color is used to consistently let the reader know if it is the adult or children graph. A brief description and picture of the experiment is included on the poster to help the reader understand what was measured and tested. The graphs are clear, neat, and use space very well.



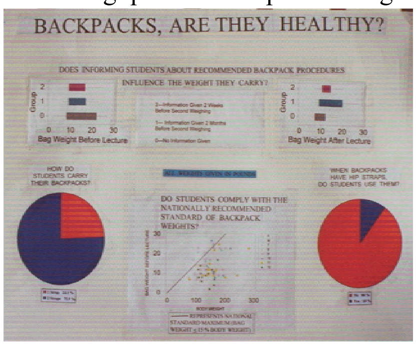
Grade category 7-9

This poster shows the results of a survey. The poster has a very nice overall appeal from the background and clear and crisp graphics. While the labels are rather small in the bar charts and take away from the overall impact, the pie charts clearly show that birthdays are the big friend buying time and Christmas is the time for family.



Grade category 10-12

This poster presented the results of an experiment. There were three groups of students involved in a pre-post test on the effectiveness of backpack education. The box plots provide a comparison between the groups and pre versus post intervention. The pie charts show the results of other backpack practices. The scatterplot shows the relationship between the backpack and body weights with a reference line for the national standard. This poster answers an interesting question and presents a good story.



ISSUES FOR POSTER JUDGING

Besides the rubric itself, several questions have arisen in the development and judging of posters. Here is some of the advice offered from the experience of judging the competitions over the years.

A good poster addresses multiple dimensions of the main title. This may include comparisons between groups (such as male and female or grades) or several questions all related to the same topic. Posters that show the same data using different graphs (a pie chart and a bar chart) may not really be enhancing the story being told by the poster. Notice that it is this multiple dimensions issue that is addressed in the overall impact of the message factor in the judging rubric.

The purpose of the competition is to tell a story with graphs. It is important to use the available space in an efficient manner. Graphs should use the majority of the poster area, taking up at least 75% of the poster. Titles can be readable without taking up a large portion. Many times the students are more concerned with the chart junk around the poster and find the graphs just a formality instead of an essential component.

Color is a powerful way to tie graphs together for comparisons. When possible, identical colors should be used to identify identical categories. Therefore, if democrats and republicans are shown in each of three graphs, purple, say, should always be republican and another color consistently used for democrat. Also, categories should be shown in the same order when possible.

Both computer drawn and hand drawn posters are acceptable and have won. The tradeoff seems to be readability versus neatness. Computer generated graphs may be neater and more accurate but they may use smaller fonts that sacrifice readability. Hand drawn graphs allow for larger fonts but may require more time to be neat and accurate (straight lines, coloring within bars). Computer graphs may require time to get colors and scales to be consistent between graphs to add to the interpretation.

Should 3-D graphics, having proliferated with the use of computer generated graphs, be used? This is a tough issue since the software and the media use 3-D graphics all the time. It is best addressed by discussing how 3-D graphs can deceive and be difficult to interpret – where does the bar end, is the pie piece bigger that shows depth – particularly when the third dimension has no meaning. Three dimensions should only be used when the third dimension means something.

CONCLUSION

Many trends have increased the need for visual literacy in today's world. Such trends include information overload and increased computer usage, globalization, and business movements such as continuous quality improvement and total quality management. Information abundance and increased computer usage make us capable of digesting huge amounts of information and quickly summarizing and presenting results. Graphics allows outcomes to be grasped at a glance without sorting through massive amounts of data. Globalization requires multicultural teams that can understand concepts and problem solve in a common language. A common language is symbols or graphic language. Flowcharts and statistics have become part of the everyday work life because they communicate so much information with few words.

The statistical poster competition allows for a unifying project within the coursework that can bring together several subjects, develop the scientific method, encourage student interest and result in a product that communicates the whole process. There is no one right way to make a statistical poster. A successful statistical poster has one unifying message throughout the poster. Decide what question is central to your study. The poster is your medium for delving into the issues surrounding this question. All material contained in the poster should have a connection to the question and that connection should be identifiable by the reader of the poster.

The focus of incorporating the project competition into the classroom is to foster positive student beliefs about the use of statistics and graphics in making choices and informed decisions. This project will allow for active participation with an emphasis on the process rather than on a single correct answer. Real data with hands-on experience will allow for the discussion of different approaches and solutions for problem solving. The poster will allow students to make connections within mathematics and statistics as well as to other subject materials. Meeting these goals will develop statistically and graphically literate citizens.

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