Section 7

Teacher Resources

The National ASA Poster Competition

By Linda Quinn

A statistical poster is a display containing two or more related graphics that summarize a set of data, look at the data from different points of view, and answer specific questions about the data.

John Tukey, in a 1990 *Statistical Science* article said, "Much of what we want to know about the world is naturally expressed as phenomena, as potentially interesting things that can be described in non-numerical words." We collect data to describe and answer questions about phenomena. We present data to communicate our ideas to others. The purpose of a statistical poster, then, is to tell a story visually from the data about some phenomena, revealing the conclusions that can be drawn.

A poster has one major disadvantage, however. Because there is no narrator to tell the story, nor an accompanying report to discuss the data, the poster must be able to stand on its own; it should not have to be explained. For this reason, special care must be taken to present ideas clearly. Not only must viewers understand the individual graphics, but they must also understand the relationships among the graphics and how the graphics address the question(s) being studied.

The American Statistical Association sponsors a competition open to students in four grade categories: K–3, 4–6, 7–9, and 10–12. The first year for competition was 1990. Additionally, a regional structure, similar to science fair judging, was established. This regional structure allows more students to be recognized for their efforts. Each region awards student posters, and then the top posters are advanced to the national competition.

Winning posters, suggestions for improving graphs, and registration information can be found at *www.amstat.org/education/posterprojects*.

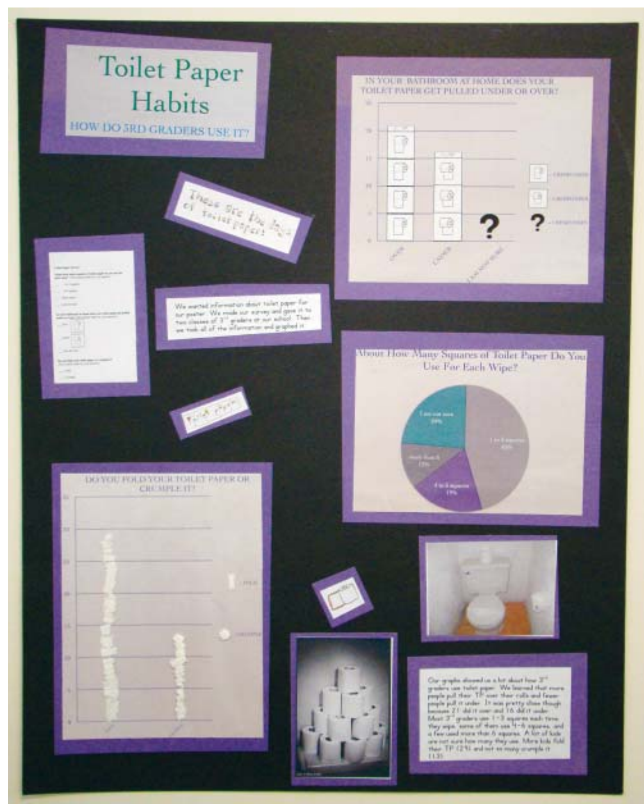
Why a Poster?

Statisticians are typically trained to graph data as the first step in a data analysis. Indeed, some would say the second step is to graph it again—in a different way. The National ASA Poster Competition is an expression of this philosophy. Sometimes, it is only in looking at data graphically that observations can be made. Graphs also complement more traditional statistical inference procedures. Posters reflect the **authors' view** of the data. Two posters using the exact same data could look very different.

Planning, Designing, and Constructing a Statistics Poster

The *Guidelines for Assessment and Instruction in Statistics Education (GAISE)* has a framework that can be aligned to the design, construction, and judging of an entry in the National ASA Poster Competition. The GAISE framework components are formulate a statistical question, design and implement a plan to collect data, analyze the data, and interpret the results in the context of the original question.

The first step in planning a statistical poster is emphasized in the first component of the GAISE framework; students should formulate a major question that can be addressed with data. Think of a major question you would like to answer, along with 3–5 sub-questions that will help answer the main question.

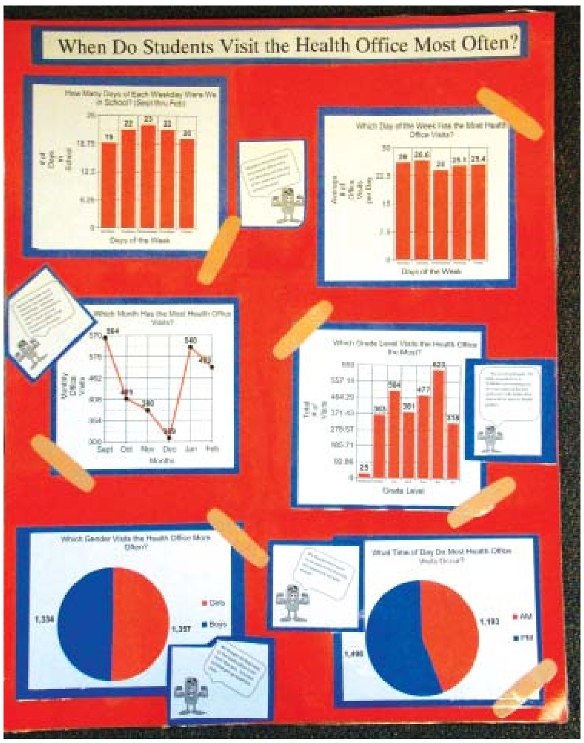


2011 first-place winner for the grades K–3 category

Remember that the central idea of the study should be the most prominent feature of the poster. This is almost always the most difficult part of entering the poster competition. So, brainstorm about things that interest your students, things they are learning about, and things they have read or seen. Statistics posters really are an interdisciplinary application. Try to encourage them to ask questions of importance to a wider audience. Avoid questions that are variations of "What's your favorite …?" and "What do you like?" You want your students to generate a question that can be answered with data, and there is variability in the data.

The second step involves the second element of the GAISE framework. Students should decide how to collect, organize, and display relevant data to answer the questions formulated. This really starts by deciding where to get the data. There are several possibilities that would result in a successful poster.

Surveys are a common source. For surveys, topics such as a person's favorite or what a person likes most are not distinguishing. Also, with surveys, students should conduct enough to make reasonable inferences. If you are collecting data from different groups of subjects, use about the same sample size, or report the data using percentages. Secondary data from the Internet or books are also possible to use. Just be careful not to simply reproduce graphs; that would be plagiarism. Students who design and collect data from an experiment are given a slight nod for creativity in data collection.



2011 first-place winner for the grades 4–6 category

Maybe just as important as where to get data is to define what type of data to collect and how that would lend itself to graphical presentation. For simplicity, consider a breakdown of either categorical or quantitative data. Is the data categorical, like favorite pizza topping, or quantitative, like how tall someone is? The type of data will dictate the type of graphs that can be constructed during the next step. The former lends itself to bar and pie charts, and the latter lends itself to histograms, dotplots, scatterplots, and boxplots. For categorical variables, try not to have too many or too few categories. Too many categories make for too many slices of a pie chart or too many bars. For quantitative data, make sure to remember the units on all graphs and in all legends.

In the third step—the third component of the GAISE framework—students will select and use appropriate statistical methods to analyze data. The analysis for the competition is mainly graphical. Graphs should be able to be read easily from six feet away and take up at least 75% of the poster space. Create appropriate graphs that show the many dimensions of the data. Usually, 3–5 graphs work best.

Each graph should display a new aspect, not be a different representation of the same data. That is, students should not simply graph the same data using a pie chart, bar chart, and pictogram. A bar chart and pie chart are both appropriate for categorical data. A pie chart is best used when the author wants the reader to compare each category as a portion of the total. A bar chart is best used when the author wants the reader to compare categories against each other. A pictogram is a special form of bar chart.

Finally, the last step—and last component of the GAISE framework—is to evaluate inferences and predictions based on data presented in the poster. Students should place themselves in an observer or reader's place. The graphs should tell the story. Students may want to annotate the poster with some of the conclusions drawn, but the answer to the questions should be clear from the graphs alone. If the judges cannot interpret it, the poster may not have told a clear story. Most of the exemplary entries in the competition pose a research question as the title or the title tells the conclusion of the research.

A **statistical poster** is a display containing two or more related graphics that summarize a set of data, look at the data from different points of view, and answer specific questions about the data.

What Makes a Winning Poster?

Judging the posters is based on the following five criteria:

1. Clarity of message
2. Appropriateness of the graphics
3. Details of the graphs
4. Creativity
5. Overall impact

Following are comments from judges and suggestions for creating a winning poster:

The **clarity of the message** is ensuring that the overall message is clear. One way for students to see opportunities for improvements here is in a peer review. Ask students to constructively critique each other's posters. What do they think the message is, and is that the story the author was trying to tell? Finally, are the conclusions obvious from the graphs, or do you want more information?

> *Dimensionality of the question* – A good poster addresses multiple dimensions of the main title or main title question. While some entries have used multiple graph types (such as bar and pie), this is not sufficient. One improvement would be to graph the overall data and then graph the data broken down by subcategories in other graphs. This is acceptable; however, in the higher grades, the graphs should be based on different questions that are all related to the main topic and not merely a breakdown by categories. This will help the reader understand the multiple facets of the question.

Considerations concerning the **appropriateness of the graphics** are about choosing the appropriate graph and doing it well. Here are some considerations for specific graph types.

Pie charts – Be careful using pie charts when the number of categories is large. The pie segments become difficult to distinguish and more difficult to interpret. When possible, consider placing the labels around the pie. It allows the viewer to make conclusions with one less step (going to the legend to figure out what category is represented by which pie segment). This also helps when the colors or patterns are really close and difficult to distinguish on the legend. If you want to make comparisons between several pies, the segments should be ordered in an identical fashion and start at a similar angle. Sometimes, a segment has zero frequency or percentage and does not show up in a pie; this can be an important fact.

Line plots – Line plots, where data points are connected with a line, are usually appropriate when the horizontal axis is ordinal or quantitative, like time. When the horizontal axis has nominal data, consider the impression the graph would have if the categories were re-ordered. The incorrect use of this graph with a categorical axis usually eliminates the poster from award consideration.

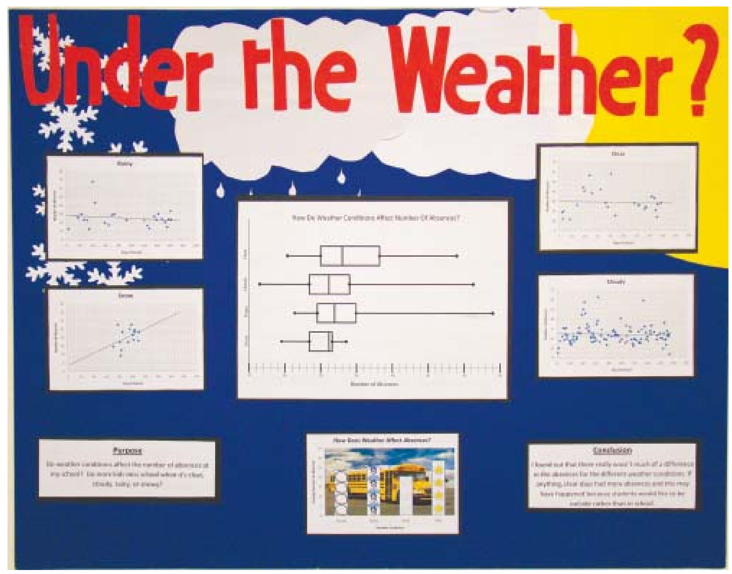
Bar charts – While bar charts can be used to show averages, you are really only conveying one number for each group. If the raw data are available, a far richer presentation in the form of boxplots or dotplots should be considered. These types of presentations let the reader see not only a measure of center, but spread and shape as well.

Stacked or cluster bar charts – Stacked or cluster bar charts are used when trying to capture the relationship between two categorical variables. A cluster bar chart is also considered a side-by-side bar chart, and a stacked bar chart would take those side-by-side bars and stack them into one bar with segments (i.e., segmented bar chart). Either graph could work. Try looking at the graph both ways. Pick the way that is clearest in its presentation. Consider the number of categories. Consider if you are using frequency counts or percents (and which kind of percents). If sample sizes are different, this is an important consideration.

Boxplots – Multiple boxplots on the same graph, or with the same scale, can be used to effectively make comparisons between groups based on center, spread, and shape. It should be remembered that a boxplot is a five-number summary and should not be used when the sample sizes are small (a rule of thumb might be fewer than 20). Also, it would be helpful to annotate the sample size on the boxplot graph. Boxplots that are meant to be compared, but are in different graphs, use different axis scales, or are drawn in differing sizes, are difficult to compare.

Scatterplots – Scatterplots do not need to have a best fit line on them, but they could. Scatterplots should be designed so the independent variable is on the horizontal axis. Sometimes, scatterplots are underused in the early grades. If the point of your questions is to show a relationship between two quantitative variables, use a scatterplot. For example, if you wanted to compare the length of your name to the value of your name in Scrabble, a scatterplot is more useful that two dotplots showing each variable individually, because now you can see the association.

Pictograms – A pictogram is a graph used often in the elementary grades. Make sure the graph is aligned to start at the same spot and each symbol is the same size. Consider putting a bar outline over your pictogram; does it make a reasonable bar chart? If not, something needs to be modified. Judges are looking for the connections between the graphs and the **details of the graphs** that enhance understanding.



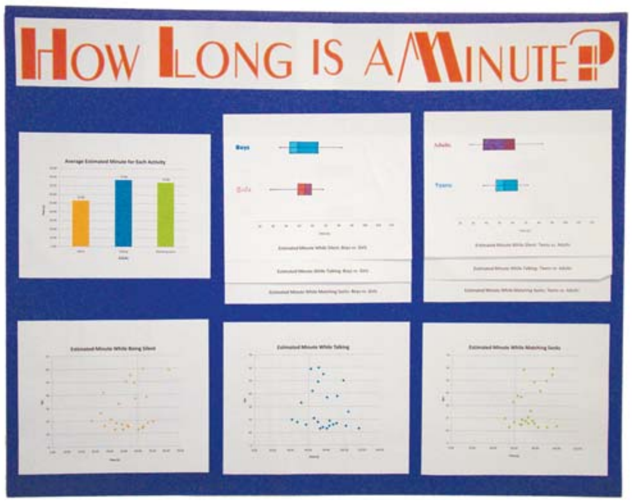
2011 first-place winner for the grades 7–9 category

Frequency versus percentage – When sample sizes are not equal and the author is trying to draw comparisons, it is better to report percentages. Percentages may not be appropriate for some K–3 students; therefore, it is important to try to make the comparison groups as equal in sample size as possible.

Axes and labeling – To ensure accurate interpretation, graphs should be adequately labeled, including labels for all axes. These labels should be spelled correctly and be large enough to read. Most times, it is preferable for quantitative axes to begin at zero. When that cannot be the case because the scale of the data is too prohibitive, there should at least be an axis break symbol used.

Grouped data – On occasion, the totals of subgroups have not made sense when compared to the total group. For example, if there were 30 males and 20 females, shouldn't the total be 50? If the grade 2 level mean is 3.4 and the grade 3 level mean is 3.6, how can the total mean be 3.9? Sometimes, this can be caught by simply proofreading the poster. If there is a reason this occurs and it wouldn't be obvious to the reader, it should be better presented.

Adjusting rates by population – Some data found in other resources or on the web, particularly geographic data, should be adjusted by the population size to make fair comparisons. If the U.S. population is larger than Cuba's, most of the statistics in terms of poverty, deaths, marriages, etc., will be, too.



2011 first-place winner for the grades 10–12 category

The use of color – Posters do not have to use color, although color may add to the overall impact. Color is a powerful way to help graphs make conclusions more readily seen. If color is an actual response, use that as the color in the graph. A graph was submitted that described the eye color preferred in a mate by the respondent. The students chose to use the color green to represent blue eyes, yellow for green eyes, and red to represent brown eyes. Imagine the judges' first impression of this data—"Red and yellow eyes!" Using a natural color, say blue for boys and pink for girls, helps the viewer quickly see relationships. Another example for choice of colors might be stop light colors—red for no, yellow for maybe, and green for yes. When possible, identical colors should be used to identify identical categories. Colors can enhance recognition of the conclusions by tying graphs with the same groups together. For example, use blue for boys in all three graphs that are showing boys.

Categorical data – When making use of the same categories across multiple graphs, show the categories in the same order if the reader is supposed to make a comparison between graphs.

Creativity is based on the creativity of the topic, creativity in the data collection, and creativity in the presentation.

Considerations concerning the **overall impact** relate to the entire poster. A winning poster, if viewed as an entire product, is readable from six feet away, is neat, has proper spelling and grammar, and tells a compelling story with four to six graphs (fewer in the K–3 category).

Use of 3-D graphics – 3-D graphics have proliferated with the use of computer-generated graphs and their use in the popular media. However, they can be deceiving to read and interpret. Where does the bar end? Is the pie piece bigger because we are comparing volume? Three dimensions should be used only when the third dimension means something other than aesthetics.

Computer versus hand-drawn – Both types of graphs 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 produce in order to be neat and accurate (straight lines, coloring within bars, circular pie charts). When generating computer graphs, students should take time to make colors and scales consistent between graphs and add to the interpretation. Increase the font size of labels, axes, and titles because posters should be readable from six feet away.

Use of space – The purpose of the competition is to tell a story with graphs. Therefore, the graphs should take up the majority of the poster. Titles can be readable without taking up a third of the poster. Graphs should take up at least 75%.

Chart junk – Edward Tufte used the term "chart junk" in *The Visual Display of Quantitative Information* and defined it as the extra graphics added to a chart or graph that add no value and distract viewers with information that isn't vital to communicate. Chart junk happens when the creativity and aesthetics of the poster become more important than the information the graph is meant to convey. There are annotations to graphs that help readers understand the data better—reference lines, for example. However, pictures used to decorate, glitter that distracts as to whether it is a point or decoration, and pictures in the background of graphs that make the graph harder to read, should all be removed.

Concluding Remarks

Certainly, students can have fun working individually or using teamwork skills. Every poster is unique. There is always an animated discussion among judges since, like works of art, each judge can see different aspects. Rarely are poster winners decided by unanimous vote, but rather by discussion of the good and poor in each presentation. Then, a ranking system is used to determine the winners.

The poster competition is one way to get students actively engaged in collecting data and drawing inferences, both vital steps in critical thinking. The poster competition also integrates many subjects. While mathematics may be the most prominent, the topic can come from any subject. The same principles that guide improved writing—write, revise, and re-write—also apply to good poster products. Artistic skills come into play in knowing the line between good aesthetic layout and overkill with decorations. Overall, many varied skills are required to tell a great story with a poster.

Resources

Bereska, C., L. C. Bolster, C. A. Bolster, and R. Scheaffer. 1998. *Exploring statistics in the elementary grades: Book one, grades k–6*. White Plains, NY: Dale Seymour.

Bereska, C., L. C. Bolster, C. A. Bolster, and R. Scheaffer. 1998. *Exploring statistics in the elementary grades: Book two, grades 4–8*. White Plains, NY: Dale Seymour.

Franklin, C., G. Kader, D. Mewborn, J. Moreno, R. Peck, M. Perry, and R. Scheaffer. 2007. *Guidelines for assessment and instruction in statistics education (GAISE) report: A pre-k–12 curriculum framework.* Alexandria, VA: American Statistical Association. *www.amstat.org/education/gaise*.

National ASA poster and project competitions rules, entry form, and previous winners: *www.amstat.org/education/posterprojects/index.cfm.*

Webinar: Working with K–12 Students to Create a Statistical Poster: *www.amstat.org/education/webinars/index.cfm*.

National Council of Teachers of Mathematics publications: *www.nctm.org*

- *Navigating through Data Analysis and Probability in Pre-K–2*
- *Navigating through Data Analysis and Probability in Grades 3–5*
- *Navigating through Data Analysis Grades 6–8*

Used Numbers series (primarily data analysis): *www.pearsonschool.com/index.cfm*

STEW, Statistics Education Web, ASA peer-reviewed lesson plans: *www.amstat.org/education/stew/index.cfm.*

The National ASA Project Competition

By Linda J. Young and Megan Mocko

In 1987, the ASA/NCTM Joint Committee, through the efforts of member Dwayne Cameron, initiated the National ASA Project Competition. The statistics project is a fun and natural way to meet the educational demands for integrating the curriculum and writing in the content area.

The project competition website, *www.amstat.org/education/posterprojects*, defines a statistics project as "the process of answering a research question using statistical techniques and presenting the work in a written report." There have been three categories: grades 4–6, 7–9, and 10–12. (As of 2012, grades 4–6 is not available.) Single entrants or teams of 2–6 may develop a project. The following six components are emphasized in the judging:

1. Question of interest
2. Research design and data
3. Collection and analysis of data
4. Conclusions
5. Reflection on the process
6. Final presentation

In evaluating the final presentation, the creativity of the project and quality of the written report are considered. Each project is read by at least one teacher and one statistician. The statistical methods become more advanced with each age category, yet, in each case, students selected a question of interest to them, collected data to answer the question, analyzed the data, and answered their question of interest. As of 2012, the ASA/NCTM Joint Committee is no longer offering the project competition for grades 4–6. Following are descriptions of winning projects in each age category, including grades 4–6 as an example of an excellent project.

1995 Winning Project, Grades 4–6

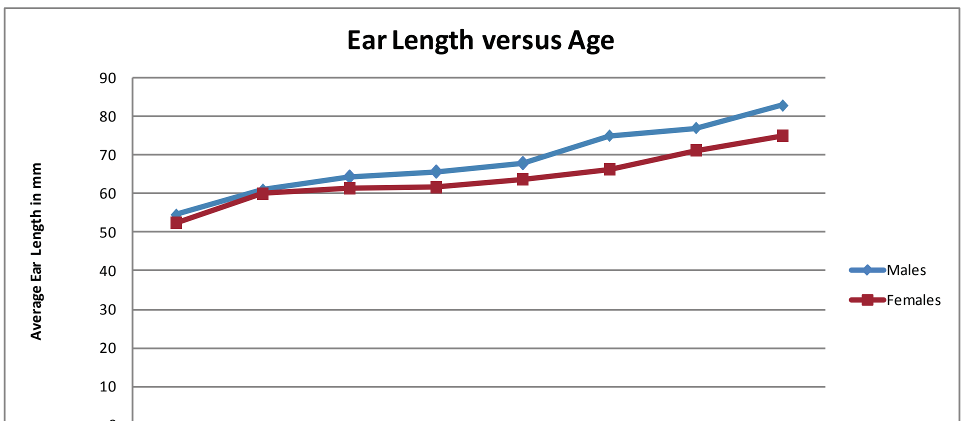
"Do People's Ears Grow Throughout Their Lives?"

This project was motivated by a newspaper article reporting the results of a British study that concluded men's ears do grow throughout life. When the students looked up the published article, they learned that everyone in the

British study was at least 30 years old. Further, men and women had their ears measured, but the report did not consider any effect of gender. Therefore, the students decided to build on this study by measuring the ears of all ages, from very young to very old, and determining whether ear growth was the same for both genders.

The students practiced measuring ears using clear plastic rulers until they consistently got the same measurements to within 1 mm. They prepared data sheets to record the age, gender, and ear measurement for each person. Because the British doctors always measured the left ear, they decided they would only measure the left ear. Then, they began looking for ears!

They measured ears at school and events they attended. One day, when they were out of school, the students set up a booth at a student union of a local university. To get younger children, they enlisted the help of a local day care center. For confidentiality reasons, the day care workers had to make these measurements. The students contacted a nursing home in an effort to measure ears of older adults. This was not permitted because of privacy concerns. Instead, they set up an area in the fellowship hall between services at their church, where they measured ears of all ages, including many older adults. In all, they measured 340 ears (compared to 206 in the British study).



	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70 over
Males	54.5	61	64.4	65.7	67.9	75	77	82.8
Females	52.4	60	61.4	61.6	63.7	66.3	71.2	75

Once they had the ear measurements, they entered the data in a spreadsheet. This is when they began wishing they had not measured quite so many ears. They grouped the data into age categories: 0–9, 10–19, 20–29, 30–39, 40–49, 50–59, 60–69, 70–79, and 80–89. They made a dotplot of the ear measurements, using different colors for each age category. Black dots were placed in the middle of the colored dots to represent males. The students also made a table for male's ears and another for female's ears, giving the average, minimum, and maximum observed ear lengths within each age category. Bar charts helped them consider how many ears they measured within each age and gender category. Finally, they drew a line plot of the average ear length for each age category, putting the female and male lines on the same plot.

Based on the graphs, the students concluded that ears do grow throughout life. Under the age of 20, male and female ears grow about the same. After the age of 20, ears of both females and males continue to grow, but at a slower rate, and male ears appear to grow a little faster than female ears. They discovered that male ears tend to be a little larger than female ears after the age of 20.

In reflecting on the process, the students noted they had enjoyed the project. It allowed them to meet and talk to many people of all ages and sizes. People enjoyed participating in the project, often laughing. Some would come back with a friend who wanted to participate.

At the day care center, the people who measured the youngest children's ears had only measured to the nearest centimeter. The students did not use these data, and it meant they had few children under the age of one in the study. They decided they should have provided more detailed instructions to the day care workers. The students also found they had several new questions, such as Does wearing earrings affect how rapidly a female's ears grow? and Do other parts of the body grow throughout life?

The project's text was slightly more than four pages. The newspaper article and journal article describing the British study were included at the end. All the data sheets were placed in an appendix, as well as a page of the typed data after it was entered on the computer. The four graphs, each on a separate page, were included. Only the minimum and maximum values were used to provide a measure of variation. Since these were fifth-grade students, that was taken as acceptable. For older students, something such as parallel boxplots of each age group would have been expected.

2008 Winning Project, Grades 7–9

"Rip Current Awareness and Knowledge: A Study of What Beachgoers Know About Rip Currents and the Effectiveness of the NOAA, Sea Grant, and LAA Outreach and Education Program"

Knowing that rip tides can be deadly and a major cause of death to beachgoers, students decided to survey beachgoers about their knowledge of rip tides. At the time, NOAA's National Weather Service, the National Sea Grant Program, and the United States Lifesaving Association were conducting an ongoing outreach campaign through signs and brochures to inform the public about the danger of rip tides. So, the students were additionally interested in estimating the effectiveness of this campaign. They wanted to know what proportion of the beachgoers knew each of the basic facts about rip tides and what proportion had seen the signs and brochures generated by the campaign.

An interesting twist to the study was that one beach area, Long Beach Township, did not post the signs or distribute the brochures. They did, however, distribute their own brochure. This is important because Long Beach Township is in the center of the research area (the 18-mile-long barrier island) and, due to the layout of the roads, must be trespassed to get to the outer reaches of the barrier island. The township also accounts for 66% of the 18-mile barrier island that was surveyed.

To determine the effectiveness of the campaign and assess the beach-going public's knowledge of rip tides, the survey was administered to a total of 1,200 people—400 each during June, July, and August. The survey also was given out at all times of the day (morning, afternoon, and evening) and at six beach locations: Barnegat Light, Beach Haven, Harvey Cedars, Long Beach Township, Ship Bottom, and Surf City. The sampling method was not haphazard, but a carefully designed stratified-cluster sampling technique.

The survey was comprised of 20 questions, including demographic questions and questions about rip tides and the campaign. Some of the questions were as follows:

Have you received any rip current materials such as a brochure?

A) No

B) Yes, When I Bought My Badge

C) Yes, from the town municipal office

D) Yes, from a local business establishment

E) Yes, Other:___________

Have you seen any rip current safety signs on Long Beach Island?

A) No

B) Yes, as I entered the Beach

C) Yes on the lifeguard stand

D) Yes, other: ____________

Rip currents …

A) Occur every day on many beaches

B) Occur only during high tide

C) Occur only during low tide

D) Occur only after major storms at sea

What is a sure sign that a rip current is under way?

A) A line of foam, seaweed, or debris moving steadily seaward

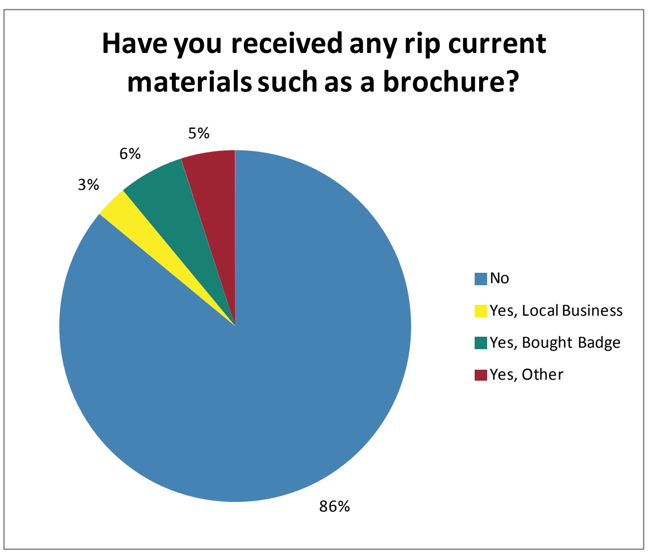
B) A break in the incoming wave pattern

C) A channel of churning choppy water

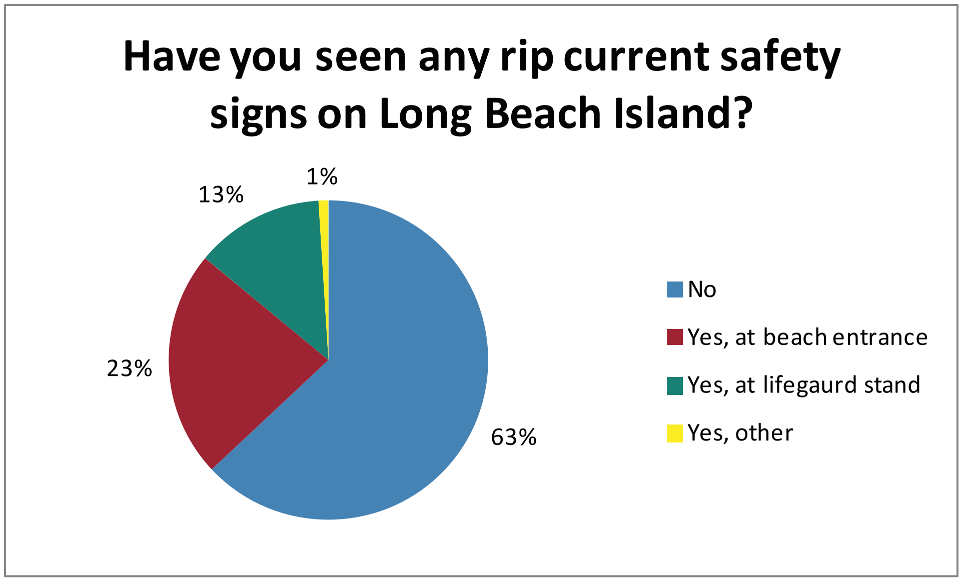
D) An area having a notable difference in water color

E) All of the above or none of the above

The researchers used pie charts and tables to summarize their findings about the proportion of people who saw signs or brochures about rip tides.



They found that 86% of beachgoers had not received a brochure and 63% had not seen any signs about rip tides. Additionally, more than 57% of those surveyed had not seen a sign or brochure. An interesting addition would have been to assess whether the beachgoers in Long Beach Township were less or more likely to have seen the signs and/or brochures compared to those using other beaches.



The survey included 10 knowledge questions about rip tides. The percent correct on these knowledge-based questions ranged from 21% to 82%.

The students learned from their experiences during the survey process. For one of the knowledge questions, an answer choice was "none of the above or all of the above." When analyzing the data, they realized that having the two extremes within one answer choice made interpretation challenging.

The students concluded that more outreach was necessary to inform beachgoers of the dangers of rip tides and that many people were not being reached by the current campaign efforts.

The students thanked several professional researchers at NOAA, the University of Delaware, NWS, Coastal Research Center, and NJ Sea Gran and a Long Beach Township rip current advocate for their help during the project. Students are not penalized for asking for professional help on a project, but are asked to address in which way(s) they received help.

The project was 45 pages long, but most of its length was due to a large appendix, large font for the text, and large graphs. The base of the paper was 16 pages long, including a title page, abstract, two-page introduction, 3.5 pages of explanation of the methodology, 6.5 pages of results, and four pages that summarized the results. The remaining 29 pages were in the appendix, which included the survey, summary statistics, and graphs for each question on the survey.

2010 Winning Project, Grades 10–12

"Edifying Experimentation"

Noticing the increasing difficulty of getting into college, four students wanted to know what they could do to help themselves be accepted. Deducing that better studying and memorization skills could increase their chances, they decided to study students' memorization skills and their possible association to grade point average (GPA). The students were interested in determining whether visual or auditory learning memorization techniques worked better and whether there was a linear association between memorization ability and GPA scores.

First, the young researchers asked 34 participating students to memorize two strings of numbers, one for each learning method. For one string of numbers, they were allowed to look at the string, whereas they had to listen to the other string of numbers from a tape recording. The students were asked to flip a coin to determine what learning method they would use first: auditory or visual.

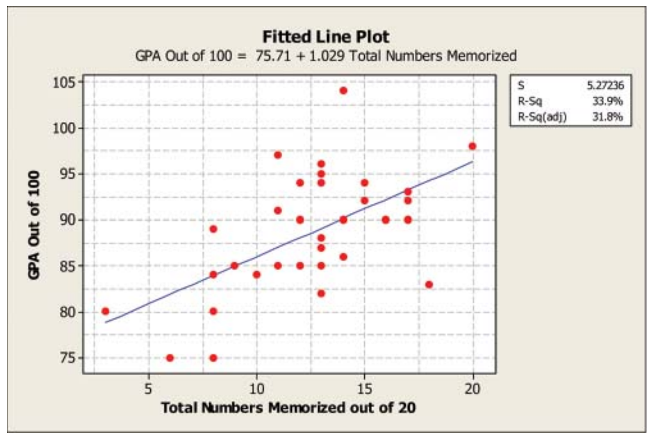
The students were given the number 3741629538 for the visual method and 6409572185 for the auditory method. Both numbers were randomly generated by a calculator. Each time, the students were given 30 seconds to memorize the numbers. They were then immediately asked to recite the number. For each method, the participants were scored based on the number of values correctly identified. For example, if the participant correctly remembered three numbers in the sequence, their score was a "3" for that method.

One of the characteristics that led this project being highly ranked was the careful thought given to the study's design. Flipping the coin to determine the order of treatments, generating random strings of numbers to memorize, and using the video recorder to recite the numbers reflected good attempts to control bias.

Because each participant used the visualization method and auditory method, the students properly conducted a significance test and constructed a confidence interval for a matched pairs design. The careful approach to checking assumptions and clear and precise conclusion statements were also strengths of this project.

Hypothesizing that the visualization method would have a higher population mean number of values remembered than the auditory method, they found there was a statistically significant difference with a *p*-value equal to 0.0000002. They computed a confidence interval for the population mean difference in numbers remembered between the visualization and auditory learning methods. They found that population mean number of values remembered for the visualization method was between 1.84 and 3.98 more values than with the auditory method, with 95% confidence.

The students also investigated the association between GPA and the memorization ability score. To do this, the memorization score was found by adding the two scores from the visualization and auditory learning methods. The significance test for the null hypothesis that population slope was equal to 0 resulted in a small *p*-value (0.000302), and the students concluded there was evidence of an association between GPA and the memorization score.



After making these conclusions, the students took some time to reflect on ways to improve the project. They mentioned that self-reported GPAs might be unreliable and, if they did this project again, they would attempt to gain parental permission to verify the GPAs with school records. They also would consider using a different sequence of numbers for the auditory method since some students found the "57" in that sequence easier to memorize than other numbers. Because some sequences are easier to learn than others, the design could have been improved further by generating new random sequences for each student and memorization method. This would allow each method to have an equal chance of getting an easy or a difficult sequence for each student.

The project was 12 pages in total with one title page and three pages of data tables and illustrations. The introduction and project description made up one page. The formal statistical inference techniques used were described and results shown in six pages, and the conclusion was one page.

Final Thoughts

Good projects have some common elements, irrespective of grade level. First, the research question(s) must be clear. Then, data must be collected that can answer the question. As an example, while the research question, "Are boys or girls smarter?" is certainly interesting and clear, students do not have the ability to collect data that can truly answer that question. Also notice that the questions being posed in the studies described above are all fairly simple ones. A simple, well-thought-out study is better than a poorly conducted complex study. As the research questions become more complex, they become increasingly more challenging to answer.

The design of the project's study is important. If humans are involved in the study, the confidentiality of the results must be ensured. If either humans or animals are involved, then care must be taken to ensure none are harmed. Proper replication is important. Careful thought should be given to controlling the extraneous variation that may be present. Reasonable measures should be taken to prevent bias.

Graphs should be used for all studies. Each graph should be appropriate for the data collected. They should be easy to read and effectively labeled. Using graphics such as 3D plots, just because they are fancy, should be avoided. The best graph is the one that helps the reader see how the data answer the question.

For *statistical* projects, care must be taken to provide the best possible analysis of the data. For younger children, finding a measure of central tendency and variation may complement the graphs in answering the question. As students mature, both the graphs and analyses become more involved. Students in grades 10–12 should include some type of formal inference, such as simple linear regression or comparing two independent proportions. As part of that process, they should ensure the following:

a. The null and alternative hypotheses are explained
b. The assumptions are checked
c. Confidence intervals and *p*-values are stated when appropriate
d. Conclusions are stated. An informal, nontechnical conclusion also should be given.

Finally, clear communication throughout the project is critical. The reader should easily be able to understand the research question and why it is important. The manner in which the study was conducted should be clear. The analysis of the data should be carefully displayed, and the results and conclusions should follow from the analysis. Because challenges arise in all studies and investigators learn how to do things better, some time should be spent reflecting on the process, suggesting improvements to the current study and discussing any new questions that might have arisen in the process of answering the present question.

American Statistical Association Online Resources

The American Statistical Association (ASA) is the world's largest community of statisticians. The ASA supports excellence in the development, application, and dissemination of statistical science through meetings, publications, membership services, education, accreditation, and advocacy. Members serve in industry, government, and academia in more than 90 countries, advancing research and promoting sound statistical practice to inform public policy and improve human welfare.

Statistics and probability concepts are included in K–12 curriculum standards, particularly the Common Core State Standards, and on state and national exams. One of the ASA's goals is to improve statistics education at the K–12 grade level and provide support for K–12 classroom teachers. Following are some of the online K–12 educational resources the ASA provides. For more information, visit *www.amstat.org/education*.

STatistics Education Web (STEW)

STatistics Education Web (STEW) is an online bank of peer-reviewed lesson plans for K–12 teachers. Through STEW, the ASA is reaching out to K–12 mathematics and science teachers who teach statistics concepts in their classrooms.

STEW is a searchable database, and its content identifies both the statistical concepts being developed and the age range appropriate for its use. The statistical concepts follow the recommendations of the *Guidelines for Assessment and Instruction in Statistics Education (GAISE) Report: A Pre-K–12 Curriculum Framework*. The website resource is organized around the four elements in the GAISE guidelines: formulate a statistical question, design and implement a plan to collect data, analyze the data by measures and graphs, and interpret the data in the context of the original question. Teachers can navigate the site by grade level and statistical topic. For more information, visit *www.amstat.org/education/stew*.

Statistics Teacher Network

Statistics Teacher Network (*STN*) is a newsletter published three times a year by the American Statistical Association/National Council of Teachers of Mathematics Joint Committee on Curriculum in

Statistics and Probability for Grades K–12. *STN* is a free publication whose purpose is to keep K–12 teachers informed about statistical workshops; programs; and reviews of books, software, and calculators. In addition, articles are included describing statistical activities that have been successful in the classroom. Contributors come from all levels of statistical expertise. For more information, visit *www.amstat.org/education/stn*.

Census at School

U.S. Census at School is an international classroom project that engages students in grades 4–12 in statistical problem solving. Students complete a brief online survey, analyze their class census results, and compare their class data with those of random samples of students in the United States and other countries.

This international program began in the United Kingdom in 2000 to promote statistical literacy in schoolchildren by using their own real data. The program is operative in the UK, New Zealand, Australia, Canada, South Africa, Ireland, Japan, and now the United States. The U.S. component of Census at School is hosted by the American Statistical Association's Education Outreach Program and cosponsored by partner Population Association of America.

Under the direction of their teachers, students in grades 4–12 anonymously complete an online questionnaire, thus submitting the data to a national database. The questions ask about such things as the length of their right foot, height, favorite subject in school, and how long it takes them to get to school. Thirteen questions are common to every country participating in Census at School, but each country adds its own questions specific to the interests of its students. Periodically, the national data from the 13 common questions go to an international database maintained in the UK. For more information, visit *www.amstat.org/censusatschool*.

K–12 Statistics Education Webinars Meeting Within a Meeting

The ASA offers free recorded web-based seminars on K–12 statistics education topics. This series was developed as part of the follow-up activities for Meeting Within a Meeting (MWM), a statistics workshop for math and science teachers held in conjunction with the Joint Statistical Meetings. For more information about the workshop, visit *www.amstat.org/mwm*.

Some of the webinar topics available include the following:

- A Statistician's Tour of the Common Core
- Exploring Census at School Data with Fathom
- What You Need to Know About the ASA Project Competition
- Math Is Music: Statistics Is Literature
- CSI Stats: Helping Students Become Data Detectives with the GAISE Framework
- Doing Data Analysis in the Middle School with TinkerPlots
- Working with K–12 Students to Create a Statistics Poster

For more information, visit *www.amstat.org/education/webinars*.