The Statistics Teacher Network

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Program Review...

The Data Detectives: A Student Simulation in Data Collection and Analysis

Reviewed by Susan J. Bates, Teacher of the Gifted, Rolla Middle School

The **Data Detectives Exchange** introduces students to both *Case and Field Research* and *Descriptive Research Design*. **Data Detectives** pairs classrooms of students grades one through three, four through six, and seven through nine from different geographical locations. I had read through their flyer on several occasions when preparing my next year's budget but thought that **Data Detectives** was for a much younger audience than my middle school students. Was I wrong! This program has been one of the most exciting and pleasurable activities for both my students and myself.

A variety of readiness activities are suggested to prepare students to distinguish between *Case and Field Research* and *Descriptive Research*. A lengthy introduction to research design is included for the teacher as background. It is well-written and includes creating questions and identifying variables, collecting data and developing hypotheses, deciding upon a research design as well as analysis, representing the analysis, and making inferences from the data.

The *Case and Field Research* part begins by getting the research partners to know each other. Twenty grade level appropriate questions are listed one per form similar to a 4x6 note card. Students record their responses to the questions. All twenty responses for one student are placed in a single envelope and labeled with the student's name.

My class suddenly realized how important the wording of a question is in determining how to respond and what the question was actually asking. Thank goodness the questions allow for this discussion. For example, two of the questions were "How do you wear your hair?" and "What is the shape of your eyes?" Not only did these questions lead to very interesting discussions when my students were answering them, but even more discussion followed when they received the responses from their research partners. "Round face and round eyes"—my students wondered if these features were as common as the responses suggested?

The project requests that the receiving class look for patterns and draw inferences about the characteristics of their exchange partners. A student creates both an illustrated and a narrative profile of his or her exchange partner as detailed and accurate as possible. It turned out that there were twice as many students in my class as in our exchange class. At first I was disappointed as a student from one hour had the same envelope to analyze as the second hour. How well that worked was a wonderful surprise! The two kept their work in the same folder and left notes to each other as they discussed what the other had drawn or written about the partner student, especially concerning their inferences.

The next step was to make hypotheses about the partner student from the patterns

Also In This Issue...

and relationships observed as well as their own experiences. What students did in their spare time, clubs they participated in, kind of clothing preferred, favorite hobby, etc., led to inferences about other interests and activities. By meeting the partner student through their twenty responses, students took this task seriously. The choice of "Chess Club" suggested to one student that this must be a smart student, had adults around her who could also play chess, and competed in local tournaments. To test their five to ten hypotheses, students created a short questionnaire. What does "smart" mean, how do you determine what "smart" is? As students created questions and shared them with the class, they received lots of advice on how to clarify each. The commitment students had to stating the question in the form that would elicit the type of response they needed was remarkable. In four to five class periods we had successfully completed the *Case and Field* portion of the project. We worked only two class periods a week on **Data Detectives** and the students could hardly wait to get back to their partner students to continue each time.

In comparison, *Descriptive Research* seemed a breeze to them. The class responded to the same questions but now they were to tally and represent the responses graphically. They were experienced plot makers and were ready for this challenge, they thought. Each student selected one of the twenty envelopes that contained all the responses from their partner classroom of students in grades six through eight. Seems simple enough, right? Wrong. The responses were not in the same form. A simple question of "How long have you known your best friend?" proved how important the wording of a question is. Responses were "since first grade," "since I was four," "all my life," "for three years," etc. Did discussion flourish! When asked what we would need to know to solve this problem, one of the students suggested looking back in the Case and Field data cards and finding the student's card "How old are you?" (I had noticed my students had responded in like manner when I checked for spelling and complete sentences before mailing our sets.)

At the time, I thought I should bring this concern to them but decided it would make a great discussion item later when they plotted their own responses. I am glad I waited for the class to make this discovery. Even a seemingly simple question "On the average, how many pieces of mail do you get in a week?" led us to respond in snail mail and e-mail. I wonder what the exchange class thought when they received our responses. In addition to plotting, students determined measures such as range, mean, median, mode, and then identified outliers. They

Workshop Announcement...

Teaching Contemporary Statistics with Active Learning

An ASA LearnSTAT Course

Who will benefit: All teachers of introductory statistics

Where: Joint Mathematics Meetings, New Orleans, Louisiana

When: Monday, January 8, 2001: 8:30 – 5:30 and Tuesday, January 9, 2001: 8:30 – 4:30

Content: Statistical thinking, emphasis on data and concepts and not on recipes, active learning, student projects, resources for teaching statistics

Format: Hands-on investigations in sampling and experimental design, exploratory data analysis, randomness, statistical inference

Presenters: Allan Rossman, Dickinson College and Beth Chance, Cal-Poly-San Luis Obispo

Materials: Extensive set of course notes, including classroom activities, Workshop Statistics: Discovery with Data by Rossman, Activity-Based Statistics by Scheaffer et al.

Fee: $225

Registration: Contact Judy Dill at judy@amstat.org or see www.amstat.org/education/Rossman-Chance.html

also had to write a paragraph to accompany their graph. In addition, I asked each student to create two different types of plots to add to the variety to return to the partner class.

The same number of class periods is devoted to *Descriptive Research* as to the *Case and Field Research* activities. At the time of the writing of this article, all work has been sent to our research class. While waiting for their responses, we will organize and plot our responses to the *Descriptive Research* data to have them ready to compare with the plots created by our partner class. My class is looking forward to receiving the profiles, questionnaires, graphs, and statistical summaries. A check will be made regarding accuracy and misconceptions. The completed questionnaires and feedback will be returned to the research partners. Upon return of the completed questionnaires students will be able to determine the strength of their hypotheses and inferences.

What a perfect ending to the school year. I encourage you to consider becoming an exchange partner!

The Data Detectives: A Student Simulation in Data Collection and Analysis was developed and coordinated by The Exchange Network, P.O. Box 9402, Bolton, CT 06043

Contact the author, Susan J. Bates, at sbates@rollanet.org

Handbook Review...

Minitab Handbook, 4th ed.

by Barbara Ryan and Brian L. Joiner
ISBN 0-534-37093-4,
paperback, $26.95
Duxbury Thomson Learning, 2001

The most important thing you need to know about this book is that it can be very useful to you even if you do not use Minitab in teaching statistics. It is in a class by itself, somewhere between a software manual and a statistics textbook. The first edition was published in 1976. Since then, the publishers have sold over 300,000 copies. In my experience, most people find out about it by word of mouth. Many feel that it is just the book they have been looking for.

The *Minitab Handbook* is really not a software manual, because it does not cover all of the procedures in Minitab. It does not even cover all the options and features for the procedures that it does cover. Nor is it a complete statistics textbook, because it does not go into as much detail about the reasoning behind statistical procedures as some textbooks do, although it actually says more about statistical reasoning than some statistical cookbooks.

Instead, The *Minitab Handbook* encourages you to learn both statistics and Minitab by using the latter to analyze real data sets. Because the *Handbook* assumes that Minitab will be doing all the calculations, the exercises at the end of each chapter usually ask for more than a numerical result. For example, one example concerned the uniformity in oxygen content from one location to another in a long steel bar. The bar was cut into shorter pieces, 20 of which were selected at random, and measured twice over a period of five days. The exercise first asks if the twenty samples seem to be about the same, a standard textbook question. Then it asks one to investigate whether the results varied from day to day—a bit nonstandard but worth looking into. Finally, it says, "There is a major unsuspected source of error in these measurements. Can you find it?"

As you try to answer questions like these, you gradually begin to realize that this is not a book about Minitab, but a book about understanding data. Minitab is just the tool the authors use to get the grunt work done, just as one learns to drive, not merely to drive a Ford. For that reason, the book can be valuable to anyone who wants to learn how to analyze data, whatever tools they might use. It is especially helpful if your own statistical experience is largely limited to the classroom, taking or teaching statistics courses. Most of the exercises can be done with the *Student Edition of Minitab* which costs about $65, or you can download a demo of the full version that will work for 30 days—long enough to work through the book if you do it in the summer.

The book does have some minor peculiarities that detract from its general excellence. No answers are given for the exercises. This is quite reasonable if you consider using the open-ended questions with a class, but difficult if you are trying to use the book for self-study. There are some surprising errors here and there. The usual textbook formula for the standard error of the mean is actually an

approximation for sampling from a population that is much larger than the sample. The *Handbook* says it holds for any population.

Finally, the cover seems to be statistically independent of the book's content. It says the book covers versions 12 and 13, but 13 is only mentioned in an occasional footnote. (The *Student Edition for Windows* is based on Version 12 anyway.) It mentions new material on proportions and logistic regression, but neither the index nor table of contents mentions either. (Admittedly, the index is rather short, but not shorter than the list of topics on the cover!) In addition, the cover is decorated with an artist's impression of a pie chart that rates an F- as a statistical tool. Even so, working through this book will teach you more about real world statistics than doing all the computational exercises that litter most introductory statistics textbooks. If the cover offends you, rip it off.

Reviewed by Robert W. Hayden
Plymouth State College
Plymouth, New Hampshire
hayden@oz.plymouth.edu

Statistics in the Classroom...

Spinning for Confidence

Marie A. Revak,
United States Air Force Academy

Spinning for confidence is an exercise that allows students to collect proportion data quickly and easily. Because of the design of the exercise, students build confidence intervals based on their own data and compare their intervals to the true population proportion.

To conduct the activity, create a worksheet that contains a large circle divided into four or five unequal wedges. Don't use 25% or 50% wedges—you'll see why later. Keep track of the size of the wedges (the proportion of each wedge to the entire circle). You can create this graphic using Excel's chart wizard or similar software. Be sure to number or label the wedges. Give each student a copy of the worksheet and a paperclip. Students use the paperclip to create a spinner by placing the paperclip in the middle of the circle, held in place by a pencil point, and then spinning the paperclip. Students can complete 50 to 100 spins in approximately 10 minutes. Have the students record the results of their spins and calculate the proportion of spins for each wedge of the circle.

Choose one of the wedges and have each student use his or her own data to create a 90% confidence interval for the proportion of spins that landed in the chosen wedge. This will take a few minutes. Each confidence interval will be unique because each student collected his or her own unique data. To ensure calculation accuracy, you may want to have students verify their neighbor's confidence interval.

Have students use the chalkboard to depict their confidence interval horizontally (like a number line). Ask the students to use the same scale and have them draw their confidence intervals directly beneath each other. After all of the confidence intervals are graphed, have students estimate the true population proportion for the chosen wedge of the circle. Ensure the students justify their estimations. Next, ask the students to estimate how many of the confidence intervals will contain the true population proportion. Again, have students justify their estimates.

Reveal the true population proportion for the selected wedge and graph its location on the confidence intervals depicted on the chalkboard. Count the number of intervals that capture the true population proportion. Lead the students through a discussion of the results by asking the following questions:

1. How does this compare to the students' estimate?
2. How does this number relate to alpha (10%) and the confidence level (90%)?
3. What would happen if we increased or decreased the number of spins?
4. What would happen if we increased or decreased alpha or if we increased or decreased the confidence level?

The swiftness of the data collection allows students to experiment with different scenarios and develop important relationships between sample size, confidence level, and alpha. Students also see firsthand the correct interpretation of a confidence interval—an interpretation that cannot be demonstrated when only one confidence interval is calculated. Students trust their own data more than data supplied by a teacher, and the technique described in this activity is easy, inexpensive, and quick. Take a spin with this activity!

Statistics in the Classroom...

Teaching Probability to Young Children – Part 2

Cyrilla Bolster
Mathematics Consultant
bolstereducation@hotmail.com

Introduction

In the spring 2000 issue of STN (54), we explored the topic of probability and kids' ideas of what comprises "fairness." We noted young children judge a game "fair" if the other players follow the rules and wait for their turn, so their notion of what is "fair" often centers around the behavior of the players. The notion of "fairness" must be examined and taught before kids can examine broader ideas about probability. By the late third grade, early fourth grade level, our goal is to help children develop a method for determining the fairness of games. To do this, students need experience with examining many games.

We need to teach students to do the following:

1) Review the rules of the game carefully, paying attention to their meaning.
2) Examine the sample space.
3) State the chance of winning (and the chance of losing).
4) Determine if it is a fair game.

To effectively analyze a game without a teacher's prompts and scaffolding, students need to internalize the four steps stated above. This four-step procedure could be shortened to a simple rule to remember:

When facing unpredictable events: review the rules, picture the possibilities, regard the risks, and be able to state your chance of success.

The Lesson

This lesson is designed to be an "Interactive-Narrative-Adventure" lesson. The teacher should prepare sentence strips for all bold statements and post them as the story is read. Tree diagrams and sample spaces can be prepared ahead of time or can be developed as part of the role-play. You may choose other enhancements (an overhead projector with pictures of a carnival, a magician, etc. and transparent number tiles to "tell" the story.) The story teller can pause at any [bracketed text] and elicit student responses, to increase the interactive role-play nature of the story. The narrative is told in two episodes. This is part two of the story. Part one was in the last edition of STN.

PART II

Outsmarting the Magician at the Carnival Games

Here is the continuing story of the kids at the carnival. Let's see how they "Fair" (so to speak).

Remember that pesky Magician? He is back! He comes to the fair each year. He has card tricks and dice games and he enjoys surprising people so that they are in awe of his powers. He seems only slightly sinister...almost likeable...and it is unnerving that he uses dice and cards and things you thought you understood, but he always seems to win! You want to know more. You think there must be some trick to what he is doing, because in all your years, you've never seen someone repeatedly win at a game, unless there was a trick or it was "rigged." You watch him carefully... you're planning to challenge him soon.

You ask yourself:

- **How do I know if the game is fair or unfair?**
- **What am I up against and what can I do about it?**
- **How can I be sure the game is random so I know I have a fair chance for a win?**

By having used these steps in the spring 2000 STN, you were able to detect unfair games, and you exposed the mysterious reasons why so many players have not had a fair chance to win. This time, it's your turn to suggest a game to play with the Magician.

You've thought up a good game, so you approach the Magician and say:

"I have a new game I would like to propose to you. Let's roll 2 dice and ADD them. If the sum is even, you win. If the sum is odd, I win. You present him with a list of the possible sums: **2-3-4-5-6-7-8-9-10-11-12.**" *[OR – Develop this list with the class.]*

But now that you see the list of possibilities, you panic! Oh no! "What did I get myself into?" you ask. Of course, the Magician likes what he sees because he seems to have the advantage (which is just the way he likes it!) He thinks to himself: 2-3-4-5-6-7-8-9-10-11-12 ...hmmm...11 possibilities...6 are even and only 5 are odd: It looks like an even answer has an advantage...true?

The game is fair only when it has equally likely outcomes of ODD and EVEN.

What am I up against and what can I do about it?

You decide to picture the outcomes by sketching them out.

[Option: Develop this matrix with the class. To make it easy to distinguish odds from evens, use two colors to display the sums.]

Possible sums for two dice:

1+1, 1+2, 1+3, 1+4, 1+5, 1+6 =	2	**3**	4	**5**	6	**7**
2+1, 2+2, 2+3, 2+4, 2+5, 2+6 =	**3**	4	**5**	6	**7**	8
3+1, 3+2, 3+3, 3+4, 3+5, 3+6 =	4	**5**	6	**7**	8	**9**
4+1, 4+2, 4+3, 4+4, 4+5, 4+6 =	**5**	6	**7**	8	**9**	10
5+1, 5+2, 5+3, 5+4, 5+5, 5+6 =	6	**7**	8	**9**	10	**11**
6+1, 6+2, 6+3, 6+4, 6+5, 6+6 =	**7**	8	**9**	10	**11**	12

2 occurs 1 time
3 occurs 2 times
4 occurs 3 times
5 occurs 4 times
6 occurs 5 times
7 occurs 6 times
8 occurs 5 times
9 occurs 4 times
10 occurs 3 times
11 occurs 2 times
12 occurs 1 time

[If you elicited class participation for the above, resume the narrative here.]

"Omi'gosh!" you think to yourself. "At first it looks like the odd number sums had a disadvantage, because when I looked at the first list of possibilities, there were 5 odd combinations and 6 even combinations. But now I have diagrammed all the possible ways of achieving the sums, I see things that were hidden from me before. Now I see that there are 18 possible ways to combine for an odd number answer and 18 possible ways to combine for an even number. This is a fair game because the outcome is equally likely for both odd and even."

Keeping a game random gives all the players a fair chance for a win.

The Pesky Magician proposes yet another game to play. He says: "Here is a new game you'll like. You will roll two dice. If we subtract the smaller amount from the larger amount, the possible answers are: 0-1-2-3-4-5. I'll take the answers 0-1-2 and you take the answers 3-4-5. OK? We tally the results. After ten rolls, we see who wins."

ME	**YOU**
0-1-2	**3-4-5**

Hmmm...you think to yourself...6 possibilities...3 for you and 3 for me...is it fair?

You decide to make a diagram of all the possible combinations.

[Option: Develop this matrix with the class.]

Possible differences for two dice:

6-6	6-5	6-4	6-3	6-2	6-1
5-5	5-4	5-3	5-2	5-1	
4-4	4-3	4-2	4-1		
3-3	3-2	3-1			
2-2	2-1				
1-1					

Difference of

0	**1**	**2**	**3**	**4**	**5**

[If you elicited class participation for the above, resume the narrative here.]

"Wow!" you think. "There are a lot more ways to get a difference of 0-1-2 and very few ways to make a difference of 3-4-5. I couldn't see that until I diagrammed it!"

You see that the Magician still likes to suggest games that are in his favor. You tell him that you are not interested in playing that game, because it is strongly in his favor. "Oh, but I really want to play a game with you," he says sadly. "How about if I can show you a diagram for a game so you can see all the possible combinations? If I can do that, will you play?" You are interested, but you say, "Show me first."

So the Magician excitedly explains, "In this game, you roll two dice and multiply them. If the answer is an even number, I get a point. If the answer is an odd number, you get a point. And I'm even going to show you a diagram of the combinations..."

[Option: Develop this matrix with the class. To make it easy to distinguish odds from evens, use two colors to display the sums.]

Here are the possible combinations for the products of two dice:

1	1	1	1	1	1
2	**2**	**2**	**2**	**2**	**2**
3 x 1	3 x **2**	3 x 3	3 x **4**	3 x 5	3 x **6**
4	**4**	**4**	**4**	**4**	**4**
5	5	5	5	5	5
6	**6**	**6**	**6**	**6**	**6**

[If you elicited class participation for the above, resume the narrative here.]

You think to yourself: Half the numbers multiplied are even and half the numbers multiplied are odd. It looks like the products are going to be half even and half odd. But are they?

[Option: Develop this matrix with the class. To make it easy to distinguish odds from evens, use two colors to display the products.]

You make a chart for the possible products for two dice:

1	**2**	3	**4**	5	**6**
2	**4**	**6**	**8**	**10**	**12**
3	**6**	9	**12**	15	**18**
4	**8**	**12**	**16**	**20**	**24**
5	**10**	15	**20**	25	**30**
6	**12**	**18**	**24**	**30**	**36**

1-**2**-3-**4**-5-**6**-**8**-9-**10**-**12**-15-**16**-**18**-**20**-**24**-25-**30**-**36**

[Resume the narrative here.]

"Whoa!...hold the phone!... there are only 6 possible odd products and there are 12 possible even products! The odd outcomes are 9 out of 36 possibilities, but the even outcomes are 27 out of 36 possibilities!" You realize the Magician almost pulled one over on you. Clearly in this game, "even" has a huge advantage! "Why is that?" you ask yourself...

[Option: Elicit the information below from class discussion.]

When I look at the table I built, I would have expected to see an alternating pattern, sort of like a checkerboard of odds and evens. Instead I see whole lines of multiples that are even. Anything multiplied by 2,4,6 had answers that were even. I would have expected that. But anything multiplied by 1,3,5 were half odd and half even answers. When I multiplied an odd number times an even number, I got .... An odd number answer! When I multiplied an odd number times an odd number, I got...an even number answer! This is an old rule, and since I forgot it, I was deceived by this puzzle!!

[Resume the narrative here.]

The pesky Magician watched me diagram the possible outcomes. He saw my face when I discovered that this game is NOT a fair game, so he is very surprised when I look him in the eye and say: "OK, Mr. Magician, I agree to play this game on one condition..."

He is so startled to hear me say that I will play that he says, "You will? I mean, oh, good. What is the condition?" "Every time there is an even number answer, you get one point. Every time there is an odd number answer, I get three points. This will adjust the game to make it fair. We will play until the first one scores 21 points. Agree?"

The Magician agrees, and we look forward to playing each other in lots of new games, because we each know that we have met our match. And we both also know:

- **In Games of Chance you take chances to win, but you also have a chance to lose. If you are able to state your chance of winning this will guide you in your decision to play the game.**
- **When you state your chance of winning, you can also figure out your chances of losing. This can help you to decide what you are willing to risk when playing a game.**
- **To play a game of chance, you have to cope with randomness. You never know what is going to happen in the next move or the next game. You can only predict what will happen in the general picture over time.**
- **You can "predict" a general trend, but it's not the same as foretelling the future. All you have to go on is your best advice. If you're lucky, maybe the game will "play out" to be to your advantage.**
- **To make an informed decision to play: review the rules, picture the possibilities, regard the risks, and state your chance of success.**

Editor's Note: *There is a new NSF funded project being developed for a fourth graders target audience. It is a cartoon series and Web site called "Cyberchase" and will be broadcast in the fall of 2001. This is a math adventure series in which a team of young characters travel in cyberspace, solve mathematical dilemmas and compliment each other in their learning styles and problem-solving techniques. One of the episodes is devoted to exploring the fairness of games. Cyrilla Bolster and her husband, Carey Bolster, are two of the mathematics consultants for this project. Look for series previews in your area.*

Keep Us Informed...

The Statistics Teacher Network 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 Grades K–12.

We need your letters, announcements, articles, and information about what is happening in statistics education! Please send hard copy, and, if possible, a disk written in standard ASCII text or a Word document to:

Jerry L. Moreno
Department of Mathematics
John Carroll University
University Heights, OH 44118

or **moreno@jcu.edu**

or **Fax: (216) 397-3033**

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E-mail: judy@amstat.org.

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Notes from the Editor...

Formal thanks is extended to **Tom Short** from Villanova University, STN's associate editor for the high school grades, who has moved on to become the Editor for the ASA electronic *Journal of Statistics Education*. JSE is a free double-blind peer reviewed journal of articles for the improvement of statistics education at all levels, including primary, secondary, post-secondary, postgraduate, continuing, and the workplace.

Check it out at *www.amstat.org/publications/jse*

Our new STN associate editor for the high school level is **Joyce Conway**. Joyce has just been awarded the national teacher's certificate. She is very involved with ASA's QL and DDM programs as well as an experienced teacher in advanced placement statistics. Please send any articles you would like to have in STN at the high school level to her at *jac@tallmadge.summit.k12.oh.us*. Recall that **Cyrilla Bolster** is STN's associate editor for the elementary grades, and **Susan Bates** is in charge of the middle grades. Both of them have articles in this issue.

Please send us your suggestions and articles. Thanks again to Tom Short for a job well done.

Let us know your Zip +4!

Statistics Teacher Network
c/o American Statistical Association
1429 Duke Street
Alexandria, VA 22314-3415
USA

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