The
Statistics
Teacher
Network

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Statistics in the Classroom

You Can Count on Statistics to Implement *The Standards*

Pedagogy and creativity are challenged more than ever as teachers design lessons consistent with *The Standards* without neglecting "standard mathematical content" (that is, traditional college-prep curriculum). Given the present state of flux in mathematics education, in which evaluation (represented by standardized tests like the SAT) is inconsistent with the instructional and curricular changes suggested, many teachers, *especially at the secondary level*, are not at liberty to tinker with their school's curriculum, eliminating selected "standard content" to implement "recommended instructional changes" and "recommended content." Whether it involves teaching a unit on probability and statistics, fostering mathematical communication through writing exercises in mathematics class, or implementing a project-based lesson (which can easily consume two weeks of school) the "recommended changes" take time; additional time; time that is already at a premium.

Also In this Issue...

Many topics found in the algebra I and II curricula don't readily lend themselves to the type of lessons advocated by *The Standards*; that is, project-oriented and discovery lessons that foster mathematical communication. Algebra I students must learn rote skills such as factoring, canceling, and simplifying rational expressions, just as algebra II students need to learn computational competency, simplifying radicals, exponents, and fractional exponents in preparation for later math courses. Creating and implementing a lesson that satisfies *The Standards* and the school's curricular requirements is as formidable as it is exciting.

Using a project-oriented approach, my algebra II class collected and analyzed data rendered from a survey that they authored. Statistics and data analysis naturally and effortlessly promoted oral, written, and graphical mathematical communication. Additionally, the very nature of statistics incorporates several strands simultaneously, clearly demonstrating the connections between diverse mathematical skills, many of which had been previously learned.

I deliberately opened the first class of the Statistics Unit with the following homework assignment, fully aware of my students' limited statistics education:

"Design/describe a survey to obtain information you are *truly* interested in:

A. State the goal/goals of your investigation in the title of your proposed survey. Example: "High School Seniors That Have Firmly Decided Upon Their Future Career: Who Are They and What Makes Them So Certain?"
B. Write 5-10 questions you would include in your survey.
C. Describe the type and number of people you would interview—the "sample" to be surveyed.
D. Describe how you would administer the survey. Would you personally approach

people with the survey? Where and when (time of day, time of year)? Would you mail them? Use the telephone?

The feasibility of your survey will be evaluated through class discussion. In the interest of objectivity and privacy, do not share your proposal with classmates prior to the class discussion."

Students used the balance of the period completing Applications 17, 18, and 19 from *Exploring Surveys and Information From Samples*, by Landwehr, Swift, and Watkins. The assignment introduced students to the concepts and terminology needed to critique their classmates' surveys, as well as write their own. Each Application is a brief description of an actual survey. Student pairs read and discussed each narrative, producing a written evaluation that:

1. determined if the sample of each survey was a true random sample;
2. identified the sampling technique used (such as convenience sampling, cluster sampling, or self-selected sampling);
3. described the potential bias associated with the method.

Unlike other algebra II assignments, the "solutions" to this assignment were expressed in a narrative, not a numerical, form. Foresight, analysis, and communication skills, not computational skills, were required.

As predicted, such a creative, open-ended assignment brought out the best—or worst. The quality and content of the student-authored surveys ranged from superbly designed investigations to silly, unsavory, and even pointless questionnaires. Confident that peer critique would eliminate the unsavory and silly proposals, no survey was censured: all were presented for consideration.

As an aside, an instructor need only provide a brief explanation of the "special" surveying method required to poll "sensitive questions" to dismiss interest in surveys of an unsavory/intimate nature. One such student-authored survey focused on the frequency of sexual activity (aka "promiscuity") of females aged 13 to 18 to uncover a "possible correlation between sexual activity and grades." Before we "tabled" this survey, the class was asked to take down the following notes, integral to a discussion about conducting surveys that involve "sensitive questions." Bisecting the board with two headings, "The Randomized Response Method" and "The Unrelated Question Method," I wrote their respective equations and identified the variables involved. But before I could complete my introductory explanation, a chorus of moans was heard. Apparently, the titillation derived from "sensitive questions" wasn't worth the extra work of understanding the appropriate methods of analyses.

Ultimately, the survey selected for implementation was "A Survey of Local Private High School Students." It involved securing the cooperation of four other private schools in the area. The students refined a 22-question survey that contained questions of a benign nature—yet ones that would render a thumb-nail sketch of the type of student attending a particular private high school. Some of the questions included:

What grade are you in?
How old are you?
What is your favorite class [subject]?
What's your approximate GPA?
What are your three favorite bands?
What are your three favorite clothing stores?

Awaiting the return of the completed surveys, students freely experimented with different graphical devices. Given several sets of real data, they were instructed to display each set using a pie chart, histogram, scatterplot, and line graph. In addition to constructing the pictorial displays, they also had to note the appropriateness, limitations, and applicability of each graphical device. Assigning Applications 20-25 from *Exploring Data* by Landwehr and Watkins introduced students to the scatterplot and the accompanying concepts of correlation and extrapolation. Each Application involved a written evaluation commencing with a visual assessment of a given scatterplot (in which students described the "story" being told by the scatterplot), concluding with identification of correlation (positive, negative, or no correlation), conjectures based on extrapolation, and a final summation noting if the scatterplot effectively conveyed that which it intended to convey.

When completed surveys were returned, they were color coded: a red, blue, green, lavender, or gray pencil slash across the upper right-hand corner provided a visual check against the surveys commingling while concealing the school's name, forcing students to rely more on the data generated than on their previous knowledge or notions about a school. Student pairs were assigned two questions for which they tallied the responses from each participating school, expressing each response as a number and as a percent. To facilitate observation, analysis, and comparison, the final counts were compiled on a spreadsheet. Given a copy of the spreadsheet, a little guidance, and limited instructions such as

"Look, look, look," and "Talk up whatever hunch you have with your partner," the students "instinctively" looked for very large, very small, or similar percents. They attempted to relate/correlate one question to another, sometimes arriving at unexpected conclusions. One team looked for a correlation between involvement in extra-curricular activities and whether or not most of a student's friends attended the same school. To demonstrate correlation, two scatterplots were drawn. "Percentage Per School Involved in School Activities" was plotted against "Percent of Students Whose Friends Attend the Same School" on one graph, and against "Percent of Students Whose Friends Have Graduated or Attend Other Schools" on another graph. A line of best fit was easily drawn on both graphs, showing a very clear, direct relationship: the greater the "friend attendance" at the same school, the greater the school involvement.

The final assignment involved communicating one or two (valid!) conclusions, substantiated with data, by creating a poster or by writing a report/analysis. The poster had to display the conclusions using at least two graphical devices. The written analysis had to include an introduction that described what we did and how we did it, followed by numerically substantiated conclusions or correlations, concluding with a paragraph or two that identified problems and weak links in the survey and suggestions for improvements.

As a final encouragement to those who have never taught a statistics unit, let alone conducted a statistics project, I'd like to share the following personal information that will remove any reservations that may be holding you back:

* I do not have a statistics background (just one undergraduate course), nor any previous experience conducting a survey or statistics project of this scale.
* Essentially, both student and teacher were "flying by the seat of their respective pants," but such an approach is permissible with statistics, the blend of art and science that it is.

Aware of my limited education and teaching experience in this field, I wanted someone with experience to look over my work and assess how I handled the unit. After school let out, I contacted a secondary mathematics instructor who lives in the area, renown for both her statistical background and the statistics units she regularly incorporates in her high school curriculum: Gretchen Davis of Santa Monica High School. She graciously and thoroughly examined and critiqued what I had done, from the survey itself to the validity of the students' conclusions. Her observations were invaluable. She immediately saw shortcomings that I was blind to. She pointed out the lack of randomness (we thought we had achieved!) in our sample due to how the surveys were administered. She identified (an inadvertently included!) "sensitive question" in our survey—the one about the student's approximate GPA. She performed a chi-square analysis, demonstrating its importance and place in such a project. She suggested how a pilot survey would have eliminated several of the problems we encountered.

Even in light of a number of shortcomings, no damage was done and a lot of learning—for both teacher and students—took place. So take a risk, and jump right into a statistics unit.

—Joanne Stanulonis
Crossroads School for Arts and Sciences,
Santa Monica, CA

Book Review

The Cartoon Guide To Statistics

by Larry Gonick and Woollcott Smith, New York: Harper Collins Publishers, 1993, 231 pages, ISBN: 0-06-273102-5 (paperback), $13.

I found this book serendipitously last December in a bookstore in Manhattan. After a few minutes with it, I was confident that I had made a great discovery.

The Cartoon Guide to Statistics (CGS) by Larry Gonick (cartoonist) and Woollcott Smith (professor of statistics), is an inexpensive, lively, and concise approach to the practice of statistics that is appropriate for not only teachers and students of statistics but for anyone interested in both concepts and methods sans exercises. In other words, just read and enjoy it. (The only prerequisites are familiarity with algebra, a desire to learn the concepts painlessly, and a sense of humor.)

CGS parallels practically any introductory statistics textbook at the college level and is suitable for interested high school students. Its 12 chapters are titled as follows (with the number of pages given parenthetically): What Is Statistics? (6); Data Description (20); Probability (26); Random Variables (20); A Tale of Two Distributions (16); Sampling (22); Confidence Intervals (26); Hypothesis Testing (20); Comparing Two Populations (24); Experimental

Design (6); Regression (24); and Conclusion (10). Each chapter is summarized on the last page or two. Also, there is a bibliography and a well-done index.

Chapter 1 opens with caricatures of Professor Smith (presumably) and his data (uh, date) in a restaurant, the first of many different cartoon characters found throughout the book. When they try to get a taxicab in the rain a few pages later, the concept of chance comes into play. The chapter closes with an overview of the book.

Chapter 2 starts with the Smith caricature calling for data ("Yo, students!" he shouts, which reminded the reviewer of "Yo, Adrian!" from the Academy Award-winning movie Rocky because, after all, Smith is based in Philly . . .) The concepts covered include the histogram, stemplot, summary statistics, IQR and boxplot, outliers, z-scores, and the Empirical Rule, with Gonick introducing more cartoon characters.

Many of the concepts of Chapter 3 are motivated by De Mere's question to Pascal concerning the likelihood of rolling at least one six in four throws of a single die as compared to rolling at least one double six in 24 throws of a pair of dice. Pascal put the question to Fermat (the same who gained much more fame on a different problem during and after the summer of 1993!). Gonick has it all done with delightful supporting caricatures of each person. Smith uses the usual dice examples unusually well in building up the concepts as his caricature bounces through the chapter along with that of De Mere. The three approaches to probability are introduced, followed by the addition rule, multiplication rule, conditional probability, and independence. After the De Mere dilemma is resolved, Smith closes the chapter with a clear and pertinent medical illustration of Bayes' Theorem.

In Chapter 4, discrete probability distributions are introduced by example, with empirical data compared to probability models, thus joining concepts of Chapters 2 and 3. After the mean and variance for discrete random variables are introduced, Smith gives five pages on continuous random variables, followed by a fine juxtaposition of the summation and the integral, which Smith has in the book simply to show the analogy. The chapter concluded with adding random variables, with De Mere popping up again!

Chapter 5, "A Tale of Two Distributions," refers, of course, to the binomial and normal distributions, with Gonick having caricatures of James Bernoulli and Abraham de Moivre joining Professor Smith and others. Briefly, the concepts covered are Bernoulli trials and the binomial random variables (including Pascal's Triangle) followed by the normal approximation and the normal table. Chapter 6 covers a brief discussion of sampling design (simple random, stratified, cluster, and systematic samples), along with sample size, standard error, and the Central Limit Theorem. Smith's story and Gonick's caricature of Gosset (aka Student) and his t distribution are great.

Smith and Gonick use caricatures of Holmes and Watson in Chapter 7 to contrast deductive and inductive reasoning. An archery lesson is used to present the concept of 95 percent confidence. Proportions precede means, as in Chapter 6, for small samples this time. "Chameleon Motors" is introduced to illustrate a t-confidence interval. Smith gives a concise explanation of degrees of freedom.

Chapter 8 begins with a case involving racial bias in jury selection before Smith introduces a four-step process for statistical hypothesis testing (using the p-value approach). Large and small sample significance tests are covered followed by a well-done section on decision theory in which Smith shows the difference between type I and II errors as well as the concept of power using a household smoke-detector for illustration. At the end of the chapter, as the Smith caricature helps a few course completers with their caps and gowns, Smith congratulates the reader on having completed the basics of confidence intervals and hypothesis testing. The remainder of the book applies these basic concepts to two populations, experimental design, and regression.

Just after the title of Chapter 9, "Comparing Two Populations," Smith adds the apt "in which we learn some new recipes using old ingredients" while Gonick has his caricature standing with a pot in each hand. A study that involves using aspirin to prevent heart attacks is used to discuss the distribution of the difference of two proportions along with its confidence interval and test of hypotheses. Chameleon Motors is used with their competitor, Iguana Auto, to compare sample means. Smith gives a fine "example that shows the pitfalls of mindlessly following the cookbook," followed by the paired t-test.

Smith, Gonick, and their cartoon cohorts give a fine verbal and visual treatment of the key concepts of experimental design (replication, local control, randomization), including a clear Latin Square design, while leaving the "detailed numerical analysis to your handy statistical software pack." (One of my favorite cartoons is in the local control discussion in which the cartoon characters are a male cab driver and a female passenger. She: "Take me around the block!" He:

"Lady, you're IN the block . . .") The chapter concludes with a lead-in to Chapter 11 on regression, where "you'll be able to see ANOVA up close and numerical."

Chapter 11 begins with cartoon of a thin woman and a heavy-set man in which the man exclaims, "All the big questions are about relationships!" Smith then refers the reader back to weights of students that were discussed in Chapter 2, includes the heights at this point, and draws a scatterplot. Linear regression and a fine explanation of SSE and the least-squares line are given. He continues by using a "rigged data set with only nine student height-weight pairs" to illustrate the calculation of slope and intercept, the ANOVA table, the squared correlation, and the correlation coefficient. Inference is also covered very well.

Chapter 12 touches on several important advanced and modern ideas, such as cluster, discriminate, factor, time-series, and image analysis, resampling (including bootstrapping, where Smith gives a computer simulation for 200 samples from the 92 students' height-weight pairs. As you might expect, Gonick has Smith pulling himself up by his bootstraps (shoelaces?), and some words on data quality with R. A. Fisher, the founder of modern statistics, in yet another amusing cartoon.

Although this reviewer has practically no criticism of what is included in CGS, there may have been a sin of omission, namely a chapter on multinomial experiments and contingency tables, especially as the NCTM Standards encourage that chi-square tests be included at the high school level. (See, for example, the Addenda Series booklet *Data Analysis and Statistics (1992), Chapter 6: Chi-Square: A Measure of Difference.*) Also, there are a small number of printing errors, which I expect will be corrected in a subsequent printing. Nevertheless, the book is still an ideal supplement to practically any modern elementary statistics textbook.

For Larry Gonick, this is his seventh Cartoon Guide, the other ones dealing with the history of the universe, physics, the computer, genetics, the history of the U.S., and (non)communication. For the reader, whether a teacher or student of statistics or most anyone else, this book should be an enlightening delight, in large part because of Woollcott Smith's continual encouragement via Gonick's caricature of him. And for everyone, this relatively inexpensive book would make for some profitable and enjoyable summertime reading!

—Reviewed by David Bernklau
Long Island University
Brooklyn, New York

Software Review

Understanding Statistics is a set of six IBM-compatible software programs covering a broad variety of probability and statistics concepts and is intended for first year college or self-instruction. The package is available from the Centre for Statistical Education for $28.75. The emphasis in the software is on building an understanding of the concepts and developing statistical processes.

These programs work on IBM-compatible computers (from 8086 processors and up) which have either an EGA screen with 256 K RAM on the EGA card, or a VGA screen. The programs can be loaded from a floppy diskette or transferred to a hard drive and run from there. Access and run time, as expected, are slightly better from the hard drive. The programs come on two 5.25-inch disks with the first three topics grouped on the first disk and the last three grouped on the second disk or one 3.5-inch disk. To run the software a one-word command is used depending on which program set you wish to use. The programs are menu-driven and very easy to use. While many data sets have been provided, some programs allow you to work with your own data sets; these should be stored on a separate diskette.

The User Manual, written by Vic Barnett and Peter Holmes, is very helpful when learning the software. It has a good overview of the software, detailed descriptions of each of the six modules, and flowcharts of program menus and options. This last feature, the flowcharts, is an excellent reference tool even after mastering the program. The program itself has little on-line help but is generally easy to follow. It is possible to navigate through the programs without even reading the User Manual. The User Manual also includes exercises after each module. The exercises are well thought out and would be an ideal way to learn the software and gain an understanding of the concepts being taught. The last pages of the User Manual explained the naming convention of the data sets provided. There are four types of data files: raw, integer, frequency, and bivariate. It may have been helpful to have given a listing and description of the data sets actually provided.

There are two sets of three modules each for a total of six modules. The first set of modules is called STAT A and consists of (1) discrete data and the binomial distribution; (2) continuous data and the normal distribution; and (3) hypothesis testing and confidence intervals. The second set of modules is called STAT B and consists of (1) the Central Limit Theorem and estimation; (2) simulation; and (3) correlation and regression. These programs use three different methods: interactive, demonstrative, and data processing. Most modules use all three methods. *Interactivity* allows the user to explore "What if . . ." scenarios; *demonstration programs* run with little or no interaction from the user; and *data processing* allows the user to manipulate and calculate statistics appropriate for that module. The programs also use the graphic capabilities to display plots and distributions.

Discrete data and the binomial distribution displays data numerically and graphically while exploring the interrelationship between the binomial, Poisson, and normal distributions. The program even allows for fitting distributions to supplied or user-provided data sets.

Continuous data and the normal distribution deals with creating frequency tables and the effects of varying the class sizes or endpoints. The normal distribution is shown with the capability of calculating probabilities given variate values and calculating variate values given probabilities. The normal distribution can be used with the data sets provided with probability plotting options.

Hypothesis testing and confidence intervals develops the concepts of hypothesis testing while explaining the interrelationship between power, sample size, and significance level. Tests for a single proportion or mean along with developing the corresponding confidence intervals are available.

Central Limit Theorem and estimation displays sampling distributions from binomial, uniform, exponential, and other population distributions and how they approach a normal distribution. Differences in statistics for measures of location and dispersion are explored. Examples of Bayesian estimation are also simulated.

Simulation shows the use of simulation as a modeling tool. A simple example is used to estimate pi. A more advanced simulation allows the user to simulate waiting queues at a doctor's waiting room. Differences in appointment systems and queue distributions can be examined.

Correlation and regression introduces the user to bivariate data and analysis. The regression portion allows the student to fit a line by eyeing the data and then applying the least squares principle to see where the differences are.

The software runs well and needs little explanation to get the student involved. The data files provided are diverse and interesting and are one of the best features. The simulations and demonstrative portions would even be amenable to supplementing course instruction. While the software is targeted to first-year college, many portions would also be appropriate for high school instruction and since the software runs on the simplest of microcomputers, it is a great choice for students and teachers who may not have high-powered computers available.

—Reviewed by Linda Quinn
Statistician
Cleveland, Ohio

Book Review

Data Analysis: An Introduction

by Jeffrey A. Witmer, Englewood Cliffs, NJ: Prentice Hall, Inc. 1992 vi + 122 p., paperback.

I have used *Data Analysis: An Introduction* by Jeff Witmer for two semesters now, and it certainly is an excellent source of interesting data sets and examples.

Witmer makes it clear in the preface that this thin, workbook-like paperback is intended to supplement a more traditional statistics text. He finds that questions about the sources of data and what can be learned by displaying and exploring data are often ignored or insufficiently addressed by the typical statistics textbook author, and his goal is to remedy this common deficiency.

The book is organized into three main parts that are subdivided into nine chapters:

Part I: Single Variable Techniques
- Chapter 1: Graphing Data
- Chapter 2: Smoothing Data
- Chapter 3: Transformations

Part II: Dealing with Many Variables
- Chapter 4: Bivariate Relationships
- Chapter 5: Regression Diagnostics
- Chapter 6: Multiple Regression

Part III: Miscellaneous Topics
- Chapter 7: Collecting Data
- Chapter 8: Capture/Recapture
- Chapter 9: Simpson's Paradox

Witmer has a seemingly boundless curiosity for collecting data about questions that interest him. He includes observations ranging from the numbers of french fries found in small orders at various fast food establishments to the length of time a male mourning dove was away from a nest site on trips to collect nest materials. Mixed with these personal investigations are a collection of more typical data sets such as those chosen from sports and politics, as well as some classics such as the 1970 Selective Service draft lottery and the Space Shuttle Challenger disaster data. I found the example dealing with adultery among teachers of mathematics to be quite unsettling! The biggest strength of this book is the variety of data sets that are presented in the examples.

Technically the book is sound, although in places its role as a supplement is clearly dependent on details being present in an accompanying text. For example, in a section on fitting resistant lines to data, the terms "resistant" and "robust" are never explicitly defined.

Witmer makes it clear that the computer is an important tool for data analysis, yet the text is not limited by being tied to one specific software package. Although "Data Desk" and "Minitab" are both mentioned, the examples, notation, and output are all quite generic and understandable.

The book does have a few weaknesses. In terms of organization, I would prefer that the chapter on Collecting Data be moved to the beginning of the text. Since data collection is the first step after planning an experiment, it seems appropriate to make it the first topic in the book. I also found the quality and quantity of the exercises to be rather uneven. There are no exercises to accompany the interesting chapter on Smoothing Data, and there is only one very general problem at the end of thirty pages of material on Least Squares Regression. Although the examples in these sections are quite captivating, the students reading the text are not provided with incremental problems involving specific questions for practice.

In summary, Witmer has achieved his goal of providing stimulating examples that could supplement a large number of standard statistical texts. On its own, I find the organization a bit jumbled, and the quality of the exercises uneven. *Data Analysis: An Introduction* seems to be ideal for a teacher who is rather familiar with statistics, is already working with a text but who is looking for interesting examples to supplement those in the text. Because of the wide variety of contexts for the data sets, students and teachers are bound to find at least one application in this book that will interest them.

—Reviewed by Tom Short
Villanova University
Villanova, PA

Information Request

Call for Assessment of Materials

We need your help! We are looking for examples of assessment items for possible inclusion in a forthcoming Handbook on Assessment in Statistics Education. These items are to be included in a chapter on exemplars of innovative assessment that will be of interest to both teachers and researchers. The purpose of this chapter is to demonstrate alternative ways of evaluating students' learning of statistics.

We are looking for items suitable for classroom use that measure conceptual understanding or statistical reasoning, that do not involve performing mechanical calculations or carrying out procedures. These items might be multiple choice, short answer, matching, or other paper-and-pencil formats.

Please send us any innovative items or tests that you use or have in your files. If you send a whole test, mark those items that you would like us to pay special attention to. Please include a brief statement about the level of the students with whom you have used these items. All published items and explanations of their use will be fully credited within this chapter.

Send materials to Joan Garfield, 140 Appleby Hall, University of Minnesota, 128 Pleasant St., S.E., Minneapolis, MN 55455.

From the Editor

There are many exciting projects taking place in statistics education today. The latest NSF-funded quantitative literacy program concerns statistics in science education. Look for a report of Science Education and Quantitative Literacy next year sometime. There is also hope that a statistics project can be funded to generate statistics materials for the elementary school level. I recently saw drafts of the data-driven modules to teach high school level mathematics; they are very exciting. Their scheduled completion is in 1995. Bert Gunther sent me a letter indicating a project that he has been working on at the Macomb, Michigan science and technology center. He teaches mathematics and science teachers the fundamentals of statistical design of experiments from a conceptual and graphical point of view. More to follow on this in the fall.

QL has reached outside the U.S. as well. I received a letter from professors Hardeo Sahai and Juan Vegas who wrote of a very successful three-week intensive QL program held at the Interamerican University, Ponce Campus, Puerto Rico. In addition to the instruction part, there was a very interesting half-day symposium on the role of statistics in business and government. It included the Director of the Statistics Division of the Police Department who explained how the Puerto Rican Police make use of statistics in fighting crime. The participants also visited a local industry to witness the role that statistics has played to improve and maintain the quality of its product and services.

These are very exciting times in the implementation of statistics and probability into our schools' curricula. Over the summer, take some time to write an article for STN that shares how you have been able to promote statistics education in your classroom.

Have a great summer!

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 the Curriculum in Statistics and Probability.

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 to the editor:

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