Introduction to Teaching Statistics at the Community Colleges

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Overview of Community Colleges in Los Angeles Area

▸ There are 21 community colleges in the Los Angeles area.
  - 9 of these colleges are part of the Los Angeles Community College District.

▸ Most colleges are on semester system with 15 -18 weeks

▸ Most colleges try to adhere to a full-time to part-time faculty ratio of 75: 25 within their college. In practice, the percentage of full-time math and statistics instructors may be as low as 60%.

▸ Why Students Attend Community Colleges
  - Transfer to a Cal State or UC
  - Pursue a 2 year Associate degree
  - Obtain certification or vocational training
  - Other

Statistics Courses at Community Colleges in Los Angeles Area

▶ The number of statistics courses offered at community colleges is rising.

▶ Each college offers 2-15 sections of introductory statistics per semester: about 25% night courses, 5% online courses.

▶ Some colleges offer honors math courses. Few offer honors statistics courses.

▶ Introductory statistic courses are labeled as math courses in the schedule of classes. Thus, students often refer to a statistic course as a math course.

▶ The introductory statistics courses varies from 3 -4 semester units.

▶ 2-12 different instructors teaching statistics per college

Note: Statistics for Social Sciences, Economics, Business were not part of our study

Objectives of the Study

▶ An overview of how statistics is taught at the community colleges through detailed analysis of
  - most commonly used textbooks for teaching introductory statistics
  - typical syllabi and their alignment with GAISE
  - typical teacher made exams
  - one-on-one interviews with community college instructors

Textbook Review

Objective

▸ The objective of this part of the presentation is to do an in-depth analysis of two textbooks (Triola and Sullivan) used in teaching introductory statistics in community college. Triola is used by 80% to 90% of the community colleges in Los Angeles. This analysis is based on in-depth examination of the chapters written on exploratory data analysis, sampling design and design of experiments.

I. Introducing Statistics as a "Science of Data"

Use of actual data sets in the chapter		Use of actual data sets in the exercises	
Triola	Sullivan	Triola	Sullivan
Simple small data sets are mainly used to demonstrate calculations	Small data sets are used to demonstrate calculations, some effort is placed on exploration	Simple small data sets requiring students to do calculations	Interesting data sets, quite a lot of variety
Use of Plots and visuals in the chapter		**Demonstration of the use of statistics in mass media**	
Triola	Sullivan	Triola	Sullivan
Adequate use of plots and visuals	Good use of plots and visuals, an effort is made to show the tie between plots, data, and printouts	Internet projects included at the end of the chapter. No examples provided	The context of the exercises and case studies provide the students with good examples of using statistics in mass media
Use of Plots and visuals in the exercises			
Triola		**Sullivan**	
None to very little		Quite extensively and the students are expected to engage in the data through computation and sometimes reasoning and interpretation	

II. Presentation of Material

Interesting "advanced organizer" to motivate the students and focus them		Clear statement of objectives	
Triola	Sullivan	Triola	Sullivan
Interesting examples of how statistics is useful, but not necessarily relevant to the chapter being discussed	Does not present students with examples, rather gives a summary of what the chapter will be.	Provides a list of major concepts and chapter heading	Provides a clear list of the cognitive (knowledge related) objectives.
Scaffolding: Creation of a tie between the old and new content and ascertaining that students have the pre-requisite knowledge		Modeling the calculations that the students are expected to do	
Triola	Sullivan	Triola	Sullivan
None	When pertinent, provides the students with a list of concepts along with the relevant sections and pages that they need to refer to.	Details are presented along with steps and statistical symbols.	Details are presented along with steps and statistical symbols.
Quality of definitions		Modeling the problem solving strategies that the students are expected to engage in	
Triola	Sullivan	Triola	Sullivan
Definitions are basically mathematical and not conceptual.	Some of the definitions are not comprehensive and it is preferable to present them after and not prior to the relevant case studies	Not well done. It could be said, that this in not modeled at all. It is assumed that the students can do this on their own.	The author tries to do this.

II. Presentation of Material (cont'd)

Clarification of relevant symbols and equations		Clarification of concepts underlying equations	
Triola	Sullivan	Triola	Sullivan
Well done	Well done	Poorly done, the author does not make any effort to do this	Rather well done. The author makes an effort to do this in the chapter and exercises

Depth and breath with which stepwise calculations are discussed		Depth and breath with which concepts and methods such as sampling and design are discussed	
Triola	Sullivan	Triola	Sullivan
A lot of emphasis is placed on this aspect. For instance ten pages are devoted to calculation of measures of center and spread for data involving intervals.	The author pays quite a bit of attention to this aspect.	Not enough attention is paid to discussion of sampling and design.	Sampling and design are clarified with multiple case studies and a variety of problems at different levels of challenge are offered in the exercise section

Modeling the importance of writing in statistics		Expecting the students to engage in writing through the exercises given at the end of each chapter	
Triola	Sullivan	Triola	Sullivan
Very little or no effort	Some effort	Very little or no effort	Some effort

Sample Definition of Statistical Concepts

Triola

▸ "The arithmetic mean of a set of values is the number obtained by adding the values and dividing the total by the number of values."

▸ "Variation refers to the amount that values vary among themselves, and it can be measured with specific numbers."

▸ "The variance of a set of values is a measure of variation equal to the square of the standard deviation."

▸ "Standard deviation of a set of samples is a measure of variation of values about the mean and it can be calculated by formula.."

Sullivan

▸ "The arithmetic mean of a variable is computed by determining the sum of all the values of the variable in the data set, divided by the number of observations."

▸ "Variance is based upon the difference between each observation and the arithmetic mean; that is, it is based upon the deviations about the mean."

▸ "Standard deviation is obtained by taking the square of the variance."

Sample Definitions from Sullivan are Incomplete and Vague:

▸ **Quantitative categorical variables** allow for the classification of individuals based on some attribute or characteristic.

▸ **Quantitative variables** provide numerical measures of individuals. Arithmetic operations such as addition and subtraction can be performed on the values of quantitative variables and provide meaning results.

▸ *If performing arithmetic operation is the distinguishing feature of the quantitative variables, then in the definition of qualitative variables, it should be clarified that such operations cannot be performed.*

▸ **An observational** study measures the characteristics of the population by studying individuals in a sample, but does not attempt to manipulate the variables (s) of interest. Observational studies are sometimes referred to as ex post facto (after the fact) studies because the value of the variable of interest has already been established.

▸ *No mention of how the subjects are selected.*

▸ **A designed experiment** applies a treatment to individuals (referred to as experimental units) and attempts to isolate the effect of treatment as response variable.

▸ *No mention of random assignment or how the groups are formed.*

▸ **Cluster sampling:** A cluster sample is obtained by selecting all individuals within a randomly selected collection or group of individuals.

▸ *This is vague. How would you go about selecting these groups?*

III. Exercises at the End of the Chapter

Exercises that help the students master the underlying concepts and definitions without doing calculations		Exercises that are strictly calculation and involve no context	
Triola	Sullivan	Triola	Sullivan
Rarely	Often	Majority	Some
Exercises that involve straight forward calculations and involve context		Exercises that involve calculation and require the student to see the tie between multiple concepts and methodologies	
Triola	Sullivan	Triola	Sullivan
Quite often	Quite oten	Rarely or none	A few
Exercises that require the students to apply the information to new situations		Exercises that require the student to engage in upper level thinking	
Triola	Sullivan	Triola	Sullivan
A few	Some	Rarely or none	A few
Exercises that require the students to do a project or create a product		Exercises that require the students to use technology to analyze data	
Triola	Sullivan	Triola	Sullivan
A few	A few	A few	A few
Exercises that require the students to comment on the application of statistics in mass media (newspaper articles, radio, TV, etc.)		Exercises involving the misinterpretation of plots and data; lying with statistics	
Triola	Sullivan	Triola	Sullivan
Rarely	A few	None	A few

IV. Use of Technology

Stepwise guidelines on how to use technology (TI83 and Minitab) to create the relevant outputs		Including case studies that involve computer outputs in the texts	
Triola	Sullivan	Triola	Sullivan
Often	Often	Some	Some
Including computer outputs in the exercises at the end of the chapter		Exercises that involve the use of technology and computer software	
Triola	Sullivan	Triola	Sullivan
Some	Some	A few	A few
Modeling the interpretation of computer outputs and plots		Exercises that require the interpretation of outputs and plots	
Triola	Sullivan	Triola	Sullivan
A few	Some	Rarely	A few

Overall Comments about Sullivan

▶ Clear objectives at the beginning of each section

▶ Proper scaffolding and creation of tie between the old and the new: Under a part entitled "preparing for this section", reminds the students of the concepts they need to know as well as the pages and sections that they need to refer to.

▶ Good modeling of what the students are expected to do in solving problems at the end of the chapter

▶ Definitions come before "case studies". It make more sense to have definitions come after the case studies. For example, terms like "ex-post facto" make much more sense after the students have read a scenario. When the students see a definition, they may try to memorize it without understanding it, When reading the "case study" first helps to set the stage for the definition and clarifies it

▶ Definitions are sometimes incomplete. For instance, there is no mention of lack of randomization in the description of observational studies.

▶ There are some, but not enough modeling of what the students need to do with respect to the interpretation of the plots within context as well as problems that involve upper level thinking.

▶ More emphasis needs to be placed on writing and interpretation of data from histograms. The questions are more abut eyeball estimation of percentages.

Overall Comments about Triola

▶ Too much emphasis is placed on calculations, around nine pages are spent on describing how to calculate mean and standard deviation with data presented as frequency tables.

▶ Verbal explanations, plots and equations are used to clarify computation and not concepts.

▶ Exercises are mostly computational. In the exercise section, there is a part entitled *Basic Skills* that is mainly computations and a part entitled *Beyond the Basics* which has more complicated calculations.

▶ Not enough attention is paid to concepts. For instance, not enough attention is paid to important concepts in design and sampling. Design and sampling are covered in nine pages.

▶ Definitions are basically verbalization of the mathematical symbols and not clarification of the concepts.

▶ Questions about sampling and design are mostly recall of information and recognition of sampling. There are no exercises on suggestion of proper method of sampling or whether the sampling method proposed is appropriate.

▶ Cooperative group exercises, internet projects, and critical thinking questions are included at the end of the chapter. However, none of the above is modeled or referred to in the chapter. It is assumed that the students automatically develop the above competencies.

▶ Students are expected to construct plots rather than comment on the plots created by the computer.

▶ No modeling of what the students are expected to do in thinking exercises. Interpretation of plots and tables is offered.

Summary of Textbook Review

Based on the above analysis, I think Sullivan is relatively more generative in nature compared to Triola because it places more emphasis on:

▶ Making sure that the students have the pre-requisite information for acquiring new concepts,

▶ Modeling the tie between the different dimensions of statistics including data sets, printout, and plots, and

▶ Providing the students with a chance to think about statistical concepts and methods, and engaging in when and where these concepts and methods applied.

Data Gathered

‣ 9 syllabi and 14 exams were collected from 9 instructors teaching in 6 colleges

- The exams analyzed consisted of 80% exploratory data analysis, sampling, design of experiments, measures of center and spread, plots, visuals

- In order to examine the alignment between the textbooks and the teacher made exams, we used textbooks chapters corresponding to concepts covered in the exams analyzed

‣ Interviewed 11 instructors from 7 colleges

- 10 were full time instructors,

- respondents were asked 22 questions regarding their teaching experiences in statistics,

- interviews lasted 20-60 minutes, and

- 9 were conducted in person, 3 were conducted via phone.

Background of Instructors Interviewed

Degrees (11 instructors)

▸ 8 full-time instructors hold a master degree in Applied Math, Math, or Pure Math

▸ 2 full-time instructors hold a master degree in Math and Education (former high school math teachers)

▸ 1 part-time instructor has a master degree in Statistics

Teaching Experience at the College Level

▸ Average number of statistics courses taken in college: **2.8**

▸ Average numbers of years teaching math at community college (or university): **7**

▸ Average numbers of years teaching statistics at community college (or university): **4.4**

▸ Only one instructor has experience in a statistics related occupation

▸ **5** have attended a statistics workshop within the past 5 years

Background of Students

Based on interviews with instructors:

- Some students choose to take statistics instead of a traditional math class to fulfill math requirements with expectations that
  - Statistics is not as mathematical
  - They will learn something that is useful in the real world

- For many students, this is the last 'math' course that they will take in college.

- Some students wait until the last semester before transferring or graduating (Spring) to take the course.

- Many community college students are dependent learners. They can learn as long as the instructors guide them.

Guidelines for Assessments and Instruction in Statistics Education

▸ In November 2005, the American Mathematical Association of Two-Year Colleges (AMATYC) endorsed (GAISE)

▸ AMATYC offered one workshop for preparing two year college instructors to teach with GAISE
  - Only 30 seats were available and "filled within hours"

Six Core Recommendation in GAISE

▸ Emphasize statistical literacy and develop statistical thinking

▸ Use real data.

▸ Stress conceptual understanding rather than mere knowledge of procedures.

▸ Foster active learning in the classroom.

▸ Use technology for developing concepts and analyzing data.

▸ Use assessments to improve and evaluate student learning.

Syllabus for Introductory Statistics

▶ GAISE has published a sample syllabus [handout]

▶ It is important for an introductory statistics course to have a thorough syllabus so that students are immediately aware that statistics is very different from the traditional math courses, that is when taught correctly or according to GAISE.

▶ Instructors need to spell out for the students
  ▶ the goals/objectives of the course
  ▶ what active learning is and how to be an active learner
  ▶ what statistical thinking is and how to achieve this

▶ We examined 11 introductory statistic syllabi from the community colleges.

GAISE Syllabus vs Community College Syllabus

GAISE	Community College
short description for **intended audience**	**prerequisites for the course**
detailed **course goals and objectives**	course **'catalog' description** of overall content
list of **course materials**	similar
instructional format (active learning warning)	**attendance, class participation, group work**
detailed **course requirements** of what students is expected to demonstrate	course requirements includes details around **homework assignments, labs,** etc
detailed **grading** breakdown	similar
detailed **course schedule** with titles of chapters	course schedule with **section numbers**
lesson **goals** and **objectives**	None. Some pass out lesson plans later
	How to get help: encourages students to come to **office hours,** form **study groups,** etc
	Disciplinary action: code of conduct, behavior

Overall Course Goals (not found in Typical Community College Syllabi)

Course goals articulated by instructors during interviews:

▶ Describe the differences between descriptive and inferential statistics

▶ Know how probability works as a tool in statistics

▶ When encountering statistics from the media,
- to look more critically at charts and data
- ask key questions in order to examine conclusions/statistics more closely

▶ Enjoy statistics

▶ Conclusion: Although this is not written in the syllabus, the instructors' attitudes are aligned with the new trends in statistics education

Instructors' Input Regarding Triola

▶ 80-90% of the colleges in Los Angeles area are using Elementary Statistics by Triola

▶ There is a preference to using the same textbook in the region because many part-time instructors teach at multiple colleges

Effectiveness of textbook as perceived by instructors

▶ 7 instructors interviewed were using Triola.

▶ Mixed responses on instructor's input regarding the Triola textbook.

   - 3 out of 7 do not find the book effective because they felt that it was not written for the students.

   - 4 out of 7 find the book somewhat effective because they feel that it is easily understood by the students. Many of the instructors feel that the minitab exercises, Triola lecture videos and student supplements are helpful.

   - Within each divide, there are 2 instructors who are aware of GAISE.
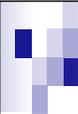
GAISE Recommendations on Assessments

GAISE

‣ Recommendation 6: Use assessments to improve and evaluate student learning.

‣ Students will value what you assess. Therefore assessments need to be aligned with learning goals. Assessments need to focus on understanding key ideas and not just on skills, procedures, and computed answers. This should be done with formative assessments used during a course (e.g., quizzes and midterm exams and small projects) as well as with summative evaluations (course grades). Useful and timely feedback is essential for assessments to lead to learning. Types of assessment may be more or less practical in different types of courses. However, it is possible, even in large classes, to implement good assessments.

Types of assessment:

‣ Homework
‣ Quizzes and exams
‣ Projects
‣ Activities
‣ Oral Presentations
‣ Written reports
‣ Minute papers
‣ Article critiques

Classification of Exam Questions

After detailed examination of teacher made exams, questions were classified into 3 major categories:

▸ Computation problems
▸ Word problems
▸ Problems involving tables and/or graphs

– **Within each category, we broke it down further by classifying problems into 3 levels (I, II, III) keeping in mind that:**

▸ All exams were closed books
▸ All (except for 2 exams) allowed formula sheets provided by the textbooks or the instructors
▸ TI-83 calculators were allowed
▸ Some problems were multiple choice

Criteria for Classification of Computation Problems

▶ **Level I:** Given the data, use a basic formula to do carry out the relevant calculations. Example: Given a set of data, compute mean, variance, standard deviation, etc.

▶ **Level II:** Given a relatively simple scenario, identify the givens that are necessary for the computation, and use the relevant formulas to carry out the computation.

▶ **Level III:** Given a complex scenario, analyze it and identify the different parts, specify the givens needed to solve the problem, and apply the relevant formulas to carry out the relevant computation.

Criteria for Classification of Word Problems

‣ **Level I:** Recall, define, and recognize facts/concepts.

‣ **Level II:** Comprehension by putting some conclusion or observation in their own words to
  - show understanding of information
  - translate meaning into new context
  - interpret simple facts, simple compare/contrast.

‣ **Level III:** Analyze, interpret, explain, evaluate and synthesize. This may require
  - breaking an idea into parts such that the relationship is made clear
  - putting pieces together to construct a pattern or idea by relating knowledge from several areas
  - making decisions about the materials or methods (ie. compare and discriminate between ideas)
  - making decisions based on evidence, verify value of evidence and recognize subjectivity.

Criteria for Classification of Problems Involving Tables and Graphs

▶ **Level 1:** Draw a graph based on data or carry out calculations from tables or graph.

▶ **Level II:** Describe properties of the given table/graph, interpret a table/graph, compare table/graphs, choose appropriate graphs, and show relationship between graph and data.

▶ **Level III:** Compare and discriminate between graphs, describe patterns in graph, recognize 'hidden' meanings in graphs, relate knowledge from several areas, draw conclusions and make decisions based on graphs/tables

Classification of Questions Given by 3 Instructors on Exploratory Data Analysis and Basic Probability Concepts

Instructor using the Triola textbook had an average of

- 76.47 % Computation Questions

- 0 % Word Problems

- 23.53 % Problems with Tables and/or Graphs

Instructor using the Triola textbook and GAISE ha d an average of

- 28.86 % Computation Questions

- 38.41 % Word Problems

- 32.73 % Problems with Tables and/or Graphs

Instructor using the Sullivan textbook had an average of

- 45.17 % Computation Questions

- 30.88 % Word Problems

- 23.95 % Problems with Tables and/or Graphs

Classification of Questions Given by 3 Instructors on Exploratory Data Analysis and Basic Probability Concepts

Instructor	Calc I	Calc II	Calc III	Word Prob I	Word Prob II	Word Prob III	Table Graph I	Table Graph II	Table Graph III
Triola	20.59	55.88	0.00	0.00	0.00	0.00	23.53	0.00	0.00
Triola w/ GAISE	0.00	15.82	13.04	2.78	28.50	7.13	2.17	16.67	13.89
Sullivan	11.87	17.12	16.18	7.14	18.38	5.36	13.03	10.92	0.00

Percentages reported in the above table are averages of 2 exams

Classification of Questions Given by 8 Instructors on Exploratory Data Analysis and Basic Probability Concepts

Instructors using the Triola textbook had an average of

- 56.15 % Computation Questions

- 27.31 % Word Problems

- 16.55 % Problems with Tables and/or Graphs

Instructor using the Triola textbook and GAISE had an average of

- 28.86 % Computation Questions

- 38.41 % Word Problems

- 32.73 % Problems with Tables and/or Graphs

Instructors using the Sullivan textbook had an average of

- 34.61 % Computation Questions

- 42.30 % Word Problems

- 23.09 % Problems with Tables and/or Graphs

Classification of Questions Given by 8 Instructors on Exploratory Data Analysis and Basic Probability Concepts

Instructor	Calc I	Calc II	Calc III	Word Prob I	Word Prob II	Word Prob III	Table Graph I	Table Graph II	Table Graph III
Triola (4)	15.92	38.88	3.49	5.03	13.39	6.17	14.34	2.23	0.56
Triola w/ GAISE (1)	0.00	15.82	13.04	2.78	28.50	7.13	2.17	16.67	13.89
Sullivan (3)	9.32	18.79	6.5	12.88	23.32	6.10	16.58	5.53	0.98

Percentages reported in the above table are averages.

Instructors' Perception Regarding Challenges in Teaching Statistics

▸ Many instructors come in with little or no statistics training.

▸ Lack of clear standards regarding teaching statistics course.

▸ One instructor felt that some instructors have the misconception that standards are related to students learning the same way they did.

▸ Some instructors acknowledge the importance of diagnostic evaluation: evaluating their students' baseline knowledge prior to starting the course.

▸ Some instructors are aware of the importance of the role that students play in their own learning. For instance, one said "it not about what I teach; it's about what the students learn."

▸ Most instructors are familiar with the importance of using real data and technology but sometimes find it difficult to do this

Instructors' Perception Regarding Student Learning

- Diverse student body (ie. full-time workers, parenting, older students)
    - Varying math skills
    - Varying study skills (ie. returning to school after 15 -20 years)

- Difficult to motivate some students to do homework

- Technology Divide: some of them work well with technology and some cannot even use the TI-83 calculator.

- Economic Divide: some can't afford TI-83, especially not for just one terminal statistics course

- Students may easily mistaken the course to be a broad survey course versus an introductory course since instructors rush to cover all the 'recommended' chapters which leads to insufficient time for students to absorb and reflect.

- Some are surprised to see how conceptual the course is. "I was never asked to think in a math course until now. . ".

Strategies that Instructors Implement to Teach Diverse Audience

▶ Many instructors do not feel that they are lowering the standards even though students have varying learning skills, math skills and time commitment.

▶ They have a variety of instructional methods: lectures, discussion, group activities, quizzes and projects

▶ Encourage students to come office hours and to form study groups

▶ In addition to exams, administer quizzes to test basic statistics skills that are essential for survive in the course. At first students despise this but later appreciate this because they realize what they need to work on.

Instructors' Use of Existing Reference Materials

▶ Many are aware of other online reference materials regarding active learning and real datasets. However, some of them reported that they did not have time to fully explore.

▶ Some of them didn't find the online materials helpful or quickly adoptable.

▶ Most of them are not aware that there are workshop materials on implementing GAISE.

Willingness to Learn about GAISE vs Willingness to Implement

▶ 9 out of 11 were interested in learning about the GAISE or new trends. Two instructors seemed uninterested or reluctant to learn due to lack of time or slight resistant to change.

▶ 8 out of 11 of the instructors interviewed seemed willing to implement some part of the GAISE or new trends if they had some examples to adopt or clear guidance. Three instructors did not have the time [willingness] to implement these changes in the near future.

▶ The 3 instructors who reported that they had not have taken any statistic courses in their undergraduate and graduate training, appeared more eager to learn what the 'right' way is.

Additional Time to Prepare for Class

▶ 3 out of 11 instructors would like to use applets or other additional technologies to teach statistics

▶ 3 out of 11 very interested in very real and relevant data sets.
  - Some feel that the data in the textbook are that relevant or real.
  - Some are not satisfy with the data found on the web since it requires too much time cleaning up or is not relevant
  - Mixed feeling about creating in class survey to use as data

▶ 7 out of 11 instructors would like to create more relevant group activities and projects

Some Suggestions By Community Colleges for Their Colleagues

‣ Administer quizzes to test basic or important skills
- First, have group discussion based on homework that was due
- Then, give a quiz based on homework and discussion

‣ Form a cohort or community of instructors at community college with weekly or bi-weekly meetings.

‣ Have a monthly or quarterly meeting among the different community colleges.

‣ Begin to implement one part of GAISE every semester (if not already doing so)

Further Steps To be Taken

▸ Interview at least 15 additional instructors

▸ Interview department dean or chair to get their perspectives on teaching statistics

▸ Conduct student surveys regarding their general feelings about statistics and the textbook

▸ Analyze additional exams and corresponding textbook chapters to get a more comprehensive picture of teaching statistics at community colleges

▸ Create sample group activities, projects, exams and lessons using very real data set and GAISE

▸ Create a partnership between UCLA professors who are interested in how statistics is taught at the community college and community college instructors.