TEACHING CRITICAL THINKING THROUGH
THE INTRODUCTORY STATISTICS CLASS

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One of the main expectations that society has from a college education is that the student will graduate knowing how to "think", and not just "think," but think critically. Yet research reported in the book "Academically Adrift" (2011) by authors Richard Arm and Josipa Roksa, show strong evidence that critical thinking skills of undergraduate college students evidence a discouraging lack of improvement in these very same skills, over the entire college experience. In fact, there is strong evidence that a substantial number of students are leaving college without any appreciable gains in critical thinking, complex reasoning and writing skills. The authors explore using the introductory statistics class as a vehicle to address these shortcomings.

The fact that there is little to no gain in critical thinking by students in the course of their college careers is not just an abstract concern to faculty and administration. With the ever increasing student tuition and debt levels, more and more people are looking at the payback from a highly expensive college education. (In fact, students are graduating with an estimated average of $29,000 debt in the US.) Businesses are also looking for similar skill sets. In a poll of employers that the Association of American Colleges and Universities released in in 2013 they found "broad support for the idea that students should learn to think critically, communicate clearly, and solve complex problems."

So what does this have to do with the teaching of the introductory statistics course? As it turns out – everything! Over the years I had been attending the annual Making Statistics More Effective in Schools and Business (MSMESB) conference where numerous pedagogical improvements in the delivery of the introductory statistics course were presented and dutifully adopted in my classroom. One example included using in-class group work to create a more active learning environment, which led to improvements in student learning and engagement.

Yet, even after dutifully adopting many of the proposed improvements, my students still showed a frustratingly lack of ability to apply statistical concepts to real life problems and situations. They often got the math "right," but they didn't get the statistics evidence part right.

I faced a quandary about how to address my student's inability to think critically and apply concepts to real world problems, as this is what they were going to be asked to do in their future careers. Only the smallest handful would ever run a t-test or even the more widely used regression in their business careers. If they did, it would not be a tidy presentation of a text-book stylized problem. What to do?

In fact, Derek Bok, the former President of Harvard hit the nail on the head. "Efforts to develop critical thinking falter in practice because too many professors still lecture to passive audiences instead of challenging students to apply what they have learned to new questions."

I realized that it wasn't my student's fault, instead the fault lay with me and my teaching methods and materials. Even though I had been teaching statistics for 20 years, it didn't dawn on me until relatively recently that statistics is an ideal vehicle to teach these essential critical thinking and communication skills. Carefully examining the use of statistics provides more than ample examples of both good and bad evidence-based thinking. So to tackle the challenges outlined above I developed a new strain of homework called Statistics as Evidence.

Statistics as Evidence is comprised of 10 different written assignments, with an average length of 500 to 600 words – a total of over 20 written pages during the course of the semester. Each assignment is designed to challenge students to think critically and write clearly by applying concepts covered in class and in readings. Students must respond to a set of specific critical prompts, with evidence based thinking, and clear writing. The assignments make up 15% of their total grade. They still have math-based homework assignments.

On the day of the assignment I break the students up into groups of three and they spend 5 minutes discussing their analyses. That is followed up by a class-wide discussion, run by me, using a random number generator to call on students. A spirited discussion often follows.

Their first assignment is entitled "Lies, Damn Lies and Statistics" and involves visiting two websites with diametrically opposed viewpoints - the National Rifle Association (NRA) and The Brady Campaign to Prevent Gun Violence – and comparing their use of data to support their different arguments and conclusions. In the course of the class, issues about advocacy, context and credibility are covered.

I tell my students, that I don't really care what their personal views are regarding guns. Even though many have strong opinions on either side, I am asking them to try and step back, and look at the numbers. Where do they come from? Are the sources trustworthy? Have the advocates used the data in an appropriate context? What about cherry-picking their evidence?

It takes some real unlearning for students to adopt a more evidence-based approach to their thinking and writing. It doesn't happen right away. I recognize this. When grading their homework, I am looking for arguments, and the data to back up those arguments. I am not looking for positions! A statistical truth is out there, but oftentimes it must be looked for in many and sometimes uncomfortable places.

To test the students improvements in critical thinking, a group of my colleagues and I performed an analysis that evaluated changes in their critical thinking between their first Statistics as Evidence homework and their seventh one that usually occurs in the 9th or 10th week of the semester. A critical thinking rubric was developed in order to compare the changes in critical thinking and writing. One of my colleagues, who was the director of the writing center for all of Saint Louis University, helped develop the rubric and did the actual grading of the two different Statistics as Evidence assignments.

The names were blinded so the grader could not tell which students had written which analysis - by this means a control for direct bias was developed. The rubric broke the changes down between both writing and thinking components. The desire here was to try and isolate the contribution of each separately. This also raised some interesting possible hypotheses to consider with regard to what comes first – writing ability or critical thinking, or both together.

After the analysis, there was evidence that in fact this strain of homework did contribute to an improvement in both critical thinking and analytical writing. The results are still preliminary, but exciting. If in fact critical thinking can be improved in one course, then this might lead to a newly targeted pedagogy in statistics and other classes that emphasize a similar approach that combines analytical writing, group and class discussion and real world problem solving in pursuit of evidence based thinking.