# USING MEDIA REPORTS TO PROMOTE STATISTICAL LITERACY FOR NON-QUANTITATIVE MAJORS

Stephanie Budgett and Maxine Pfannkuch
Department of Statistics, The University of Auckland, New Zealand
s.budgett@auckland.ac.nz

*At The University of Auckland we teach an undergraduate course entitled Lies, Damned Lies and Statistics, the purpose of which is to facilitate students to "think statistically" when confronted with evidence-based arguments. In this paper we first describe how we use media reports in teaching to enhance students' ability to understand and evaluate statistically based information. Second, we report our observations on interviews we conducted with three non-quantitative and three quantitative majors seven months after they completed the course. A comparison of their responses to two media reports does not suggest any meaningful difference between the two groups in terms of their understanding of statistically-based information. There does however appear to be a difference in the way the two groups explain their understanding. Possible reasons for these observations are discussed.*

## INTRODUCTION

- Should cell phones be banned when driving?
- Do cell phones cause cancer?
- Is there a link between food coloring consumption and children's behavior?
- Do boys achieve better in single-sex schools?

Such questions of public policy or personal choice regularly appear in the news. Yet "For lack of sufficient quantitative reasoning, both readers and reporters frequently misinterpret medical and scientific news. Overvalued anecdotes, misinterpreted percentages, and unverified studies impede thoughtful analysis of evidence" (Kolata, 1997, p. 23). Data-based evidence requires people to learn to think for themselves when faced with seemingly contradictory evidence from different sources. It requires them to understand such things as the difference between absolute and relative risk, the nature of evidence, and that what matters is how studies are done (Kolata, 1997). Statistical literacy means learning to think critically about the data's credentials, to be skeptical about "scientific" findings, and to make well-founded judgments (De Veaux & Velleman, 2008).

In our undergraduate course, Lies, Damned Lies and Statistics we aim to give students some basic foundations for critiquing and evaluating statistically based information that they encounter in daily life. Our assumption is that students can be taught these reasoning skills through using media articles as a springboard into learning about how to evaluate studies. Consequently they develop a list of "worry questions" for studies (see Gal, 2002) and further their knowledge about studies (e.g., experiments versus observational studies) and statistics (e.g., margin of error, risk). The use of media articles is in line with Kolata (1997) who believes quantitative-type reasoning can be taught by discussing news stories and explaining how to ask the right questions about the data. Students from a wide range of backgrounds enroll in our course–from statistics majors to history majors, from students confident in mathematics to mathematically-anxious ones, and from students with English as a first language to English as a third language. In this paper we describe two examples of how we use media reports in the course to enhance students' statistical literacy and then we make some observations from interviews with six students, three of whom were quantitative majors and three who were not.

## USING MEDIA REPORTS IN TEACHING

In the interviews with the six students we gave them two media items, one on a political poll and the other on an observational study involving risk.

To understand the type of learning experiences the students had encountered in the course they completed seven months before, we will briefly describe some features of activities in which they engaged during a three-week unit on polls and surveys and a three-week unit on experiments, observational studies and risk. Each unit involved 8 lectures, 3 tutorials, and a guest lecturer.

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*Polls*

> Public opinion polls are the most visible examples of a statistical application that has an impact on our lives. … A citizen informed by polls needs to understand that the results were determined from a sample of the population under study, that the reliability of the results depends on how the sample was selected, and that the results are subject to sampling error. The statistically literate citizen should understand the behavior of "random samples" and be able to interpret a "margin of sampling error" (Franklin et al., 2007, p. 1).

Students are introduced to political polls through a case study on a poll that is regularly conducted for TV One news by the Colmar Brunton market research company. For the case study they are shown a videoclip of the news item, the media article, and the polling company's report on the methodology, questions, results, and voting patterns over a number of years. By discussing this poll, issues about non-sampling errors arise such as non-response bias, selection bias, and behavioral bias. To understand ideas about random samples, sampling variability and margin of error, students view "movies" or animations of random samples with different sized samples being selected from a large CensusAtSchool database (www.censusatschool.org.nz) (Figure 1). As each random sample is drawn it leaves a footprint of the percentage behind for students to track the extent of the variability. As students watch the "movies" they note: sampling variability decreases as the sample size increases; for samples of size 1000, the sampling variability for poll percentages over 30% is larger than for poll percentages less than 10%; samples of size 1000 give a reasonable estimate of the population percentages as the distribution "settles down"; smaller samples have more variability.

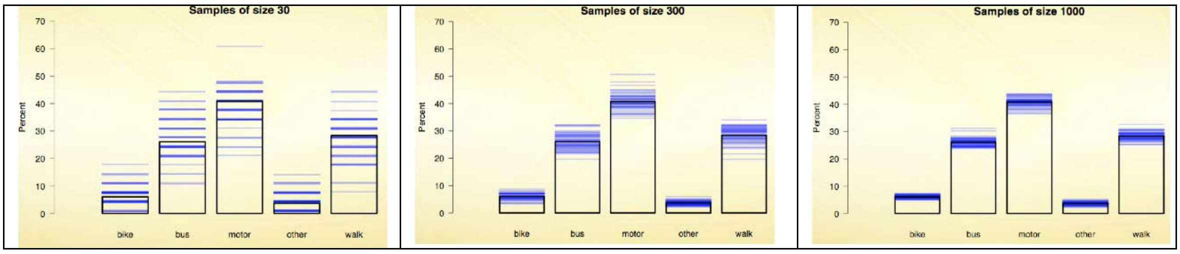


Figure 1. Bar charts with memory, n=30, n=300, n=1000 (Wild & Taylor, 2009)

Through viewing these "movies" and discussing some major ideas about sampling variability they learn about the margin of error that is reported in newspapers. They discover that the margin of error roughly applies to poll percentages between 30 and 70%, can be quickly calculated using $1/\sqrt{n}$, and gives an approximate 95% confidence interval for the true population percentage. Since most of our newspaper journalists report on and argue with estimates rather than taking the margin of error into account, students are given media-based activities and simple rules-of thumb for comparing poll percentages to check out whether claims are correct. They are also encouraged to use their general knowledge to estimate margins of error particularly when reports break down voting patterns based on gender, location, age, or household income. By using media articles on polls students learn to think about and question possible non-sampling errors including the design of the study and the questions asked, learn how to interpret the margin of error, and learn about the relationship between sample and population.

*Observational Studies and Risk*

Media articles involving commentary on observational studies are far more common than those involving randomized experiments (Schield, 2005). People are bombarded with recommendations from studies that have not been subject to experimental best practice. Furthermore, many studies reported in newspapers are fraught with issues such as the presence of confounding variables and generalizing results to populations other than those studied. Statistically literate people can assess whether a study is observational or not, and make informed judgments on the impact of any study conclusions to their daily life.

Students are introduced to the topic on experiments and observational studies through a short video clip involving the use of fish oil capsules in a primary school. A copy of the newspaper article on this study is given to students. Issues such as randomization, control groups, confounding variables, blinding and the Hawthorn effect are then informally discussed. A range of topical media reports and their associated journal articles is then presented by the lecturer and critiqued by the class. We believe that exposure to many different types of studies and subsequent critical assessment of the studies, educates students to differentiate between experimental and observational studies and to learn why causal statements cannot be made from the latter.

Media reports often dramatize the benefits or harmful effects of particular treatments or certain types of behaviors by presenting results in terms of relative risks. Media headlines such as “Drug halves breast cancer returns” and “Tea doubles chance of conception” are common. The majority of media articles reporting on risk communicate relative benefits or harms of specific treatments or behaviors, rather than absolute benefits (Moynihan et al., 2000). The statistically literate consumer understands the importance of the baseline risk in making judgments on the basis of any such study results. Furthermore, provision of information on baseline risk enables a greater understanding of risk messages (Natter & Berry, 2005).

The section on risk is introduced to students with a few “thought” statements. With the “thought” statement– “Bacon increases your risk of colorectal cancer by 20%”–they are asked how they would respond. Would it influence their decision to eat bacon? Is there any additional information they would want before making any decisions about their consumption of bacon? To understand ideas about baseline risks, increased risks and relative risks, students are shown Paling palettes (Figure 2) adapted from The Risk Communication Institute website (Paling, 2003 and http://riskcomm.com). These palettes efficiently enforce the concept of the baseline risk being a crucial piece of information that is essential for one to make informed decisions before altering one’s behavior. The first palette, showing a small extract from a 1,000 person palette, illustrates the doubling of a risk when the baseline risk is small. In contrast, the second palette illustrates the doubling of a risk when the baseline risk is substantially larger. The use of visual representations and real numbers promotes a deeper understanding of the issues of risk interpretation and equips students with the confidence to ask questions on issues such as missing baseline risks and absolute benefits or harms.

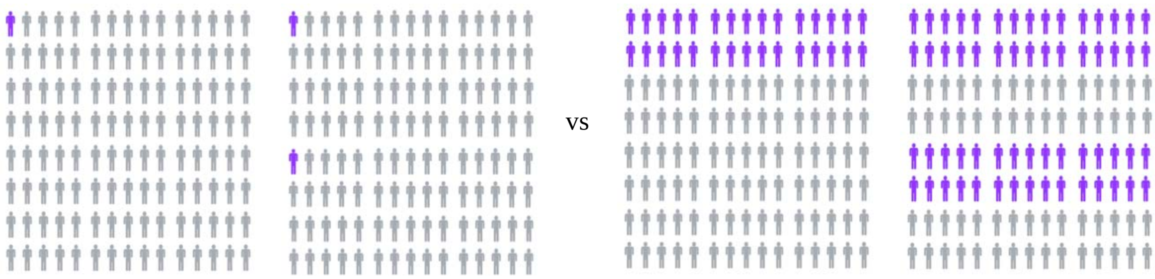


Figure 2. 1,000 person Paling palettes showing relative risk of 2 with different baseline risks

## OBSERVATIONS FROM STUDENT INTERVIEWS

The participants in this small exploratory study all took the course Lies, Damned Lies and Statistics in the second semester of 2008. They comprised three students intending to major in statistics and three students majoring in non-quantitative subjects such as history, philosophy and linguistics. This course was the only statistics paper taken by two of the three students majoring in non-quantitative subjects and all of these students described themselves as mathematically anxious. The final course grades for the six participants ranged from C to A+. Interviews were conducted about seven months after completion of the course. They were interviewed individually by us.

### *Responses to political poll*

**National retains poll position** (Source: NZP 05/04/09)
The TV One News Colmar Brunton poll tonight put National on 57 percent support (up 1 point) compared to Labour on 31 percent support (up 3 points). The Green party was on 7 percent (up 1 point), while ACT and the Maori party hovered around 2 percent support.
… 1000 votes with a margin of error of 3.1 percent…

Figure 3. Extracts from political poll media article given to students

The students were asked to read the media article (Figure 3) and respond with any questions, words, or images that came into their minds. Initial worries were about non-sampling errors such as how the sample was selected, method of contacting people, design of questions, and non-response bias. General and specific questions were then asked to probe students' interpretation of the margin of error (moe). The responses indicated there was little difference between the non-quantitative (NQ) and quantitative (Q) students (Table 1). None of them could remember any formulae but it was noticeable that the NQ students were thinking at a more conceptual level whereas the Q students tended to search for formulae.

Table 1. Student responses to political poll questions

| Student | | Margin of Error | | | | | |
|---|---|---|---|---|---|---|---|
| | | Sample to Population | Applies to ≈ 30–70% | Greens 7% | Gender split | 95% confidence | Image |
| Non-Quantitative | NQ1 | C | P | C | P | N | Parabola |
| | NQ2 | C | C | P | C | C | Fig.1 |
| | NQ3 | P | I | I | I | N | % ±moe |
| Quantitative | Q1 | C | P | C | C | N | Fig. 1 |
| | Q2 | P | I | I | I | P | [ , ] |
| | Q3 | P | C | C | C | N | [ , ] |

C=Idea understood, P=partially understood, I=not understood, N=not spontaneously mentioned.

Three excerpts from the interviews are now given to mainly illustrate NQ student responses.

I: The moe is 3.1%, so what does that information mean to you?
NQ1: Moving from the sample to the general population, it could be either 3.1% maximum greater or 3.1% maximum lesser … because the poll is always going to be an imperfect representation of the population.

In this first excerpt note how NQ1 responds to the moe with ideas about sample and population while only Q1 did so (not shown). We conjecture the three NQ students responded in this way, as they tended to look at ideas from a "big picture" perspective rather than focusing on the detail of the "numbers".

I: We're told the Greens polled 7%. What do you think the moe means for that particular result?
NQ1: I remember, the smaller the portion of the whole then the lower the moe …
Q2: Wouldn't it be the same? Somewhere between plus or minus 3.1% as the interval they could be in?

For the second excerpt we conjecture NQ1 was able to think this way as his image of a moe was a parabola, shown in class, that visually indicates the moe is at a maximum for poll percentages roughly between 30 and 70% whereas Q2's image was brackets containing an interval of plausible values for the "actual" percentage. When questioned Q2 did not attend class when the sampling "movies" were shown so they were not part of her conceptual repertoire.

I: The moe is 3.1%, so what does that information mean to you?
NQ2: Well I can remember how … like you have the graph and the bar (he gestures and also with his eyes visually shows the series of bars being generated as in Fig. 1) and there is the moe on the bottom (gestures) and you say, oh, the actual result is somewhere in here (gestures) … we're trying to extrapolate to the population in general … it's 19 times out of 20 it falls within that range … It only works for samples of 30(%) up to 70(%) doesn't it?
I: Let's think about our sample of 1000 voters. Let's split them up into males and females… What do you think the moe for that percentage would be?
NQ2: It would be double, because you've split the sample.

The third excerpt shows NQ2 responding vividly with imagery from Figure 1 and spontaneously mentioning the population, the confidence level, and the poll percentages to which the moe applies. Even though he can't remember the moe formula he knows that if the poll is split into two groups the moe will be bigger than the one reported in the newspaper. Unlike the Q students and NQ3, whose reasoning had to be really probed, NQ2's conceptual images allowed him visualize the moe.

*Responses to observational study on risk*

**Sugary drinks raise risk of gout in men** (Source: Reuters 04/02/08)
Sugar-sweetened soft drinks and fructose are strongly tied to an increased risk of gout in men... Choi, from the University of British Columbia in Vancouver … used food questionnaires to assess consumption levels of soft drinks and fructose in 46,393 men enrolled in the Health Professionals Follow-up Study who were gout-free at study entry and were followed for 12 years…
Compared with soft drink levels of less than 1 serving per month, consumption of 5-6 servings per week, 1 serving per day, and 2 or more servings per day, increased the risk of gout by 29 percent, 45 percent, and 85 percent, respectively…

Figure 4. Extracts from observational study given to students

Participants were presented with the media article (Fig. 4) and asked to respond with any questions that sprang to mind. The main issues were the type of study (observational, implications of causation), the absence of baseline risk, problems with food questionnaires, the presence of confounding variables and the problems of generalizing results. Some concerns were raised spontaneously by the students while others were raised after some discussion with the interviewers. A summary of levels of consolidation on the main issues that were raised is given in Table 2.

Table 2. Student responses to risk questions

| Student | | **Observational Study & Risk** | | | | |
|---|---|---|---|---|---|---|
| | | Study Type | Baseline Risk | Food Questionnaires | Confounding Variables | Generalizing results |
| Non-Quantitative | NQ1 | C | C | C | P | C |
| | NQ2 | C | C | P | P | C |
| | NQ3 | P | I | P | N | P |
| Quantitative | Q1 | C | C | P | C | P |
| | Q2 | C | P | C | P | C |
| | Q3 | C | C | P | P | P |

C=Idea understood, P=partially understood, I=not understood, N=not spontaneously mentioned.

An excerpt from the interviews is now given to contrast comments made by Q and NQ students.

I: What questions spring to mind when you read the article? Any worries?
Q2: Sometimes they don't interpret it in the correct way… like increased risk, it is actually other kinds of risk...but I've kind of forgotten.
Q1: Someone would read it and say 'oh, I might have one drink a day and that'd be saying I've got 50% more chance of getting gout … well that's the confusing part, isn't it? If they had a 1% chance in the beginning, its 1.5% now.
Q3: It might increase the risk by 85%, but you might only have a 2% chance of it in the first place.
NQ1: The biggest one was the baseline risk, it doesn't say how likely you are to get gout in the first place..
I: If you knew the baseline risk, how would that help you interpret the statements about risk?
NQ1: Well if the baseline risk was large I would know that it could be a genuine effect if I were to drink more soft drinks, so I might think twice about it, but if it was minimal then I probably wouldn't change my mind.

In the excerpt above note that Q2 has concerns with the interpretation of the risk statements given in the article, but is unable to articulate precisely what those concerns are. On the other hand, both NQ1 and NQ2 (not shown) have a firm grasp of the issues arising from a missing baseline risk. Both Q1 and Q3 also have a sound understanding of the problems that can arise when a baseline risk is not stated, and how it can be confusing for those attempting to quantify an increased risk. Interestingly, both of these quantitative students use numbers in their explanations, while NQ1 and NQ2 use non-numerical language. We believe that this further enforces our observation that the NQ students focus on concepts rather than detail.

## CONCLUSION

From the interviews with three non-quantitative (NQ) and three quantitative (Q) students it was very surprising to us that there appeared to be little difference between the two groups in terms of their understanding of two media articles. Since the study only involved six students and focused on margin of error and risk, we can only give some conjectures and observations about their responses. We noticed that despite the groups showing little difference in understanding, there was a difference in their approach. The NQ group seemed to have a "big picture" perspective whereas the Q group was more focused on the "detail." For example, for the margin of error (moe), visualizing a graph of sampling variability (Fig. 1) or the moe graph allowed two NQ students to re-create the detail whereas the visual image of confidence interval brackets for two Q students did not seem to convey the concept, and they had to rely more on their memories. Also formulae and "details" seemed to be forgotten while "images" could be recalled. For risk, the NQ group seemed to use their "big picture" logic to reflect on percentages of large quantities versus small quantities to imagine the problem if the baseline risk was not taken into account, whereas the Q group seemed to use numerical values in their explanations. Unfortunately we did not probe their reasoning to see if the Paling palette (Fig. 2) or some other image of risk was part of their conceptual visualization.

Since we only interviewed six students, our following conjectures and conclusions, which seem to make sense intuitively, remain speculative. We believe that these students were developing statistical literacy with regard to polls as defined by Franklin et al. (2007) and to risk as defined by Utts (2004). Students were also using "worry questions" (Gal, 2002) or tools to think for themselves when responding to media reports. Promoting and enhancing the statistical literacy of non-quantitative and mathematically anxious students seems to be possible using media reports as discussion starters (Kolata, 1997) and as stepping stones to increase their knowledge about statistically–based studies and statistics. As long as the teaching approach is *conceptual* and *visual*, and not bound up in calculations, non-quantitative majors can acquire some basic foundations for evaluating and critiquing statistical information encountered in everyday life and can become statistically literate using the medium of media reports.

## ACKNOWLEDGEMENT

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