

TEACHING STATISTICS FOR ENGAGEMENT BEYOND CLASSROOM WALLS

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Statistics education organizations have recently increased efforts to help broader audiences view statistics as a ubiquitous and positive domain. At the same time, educators increasingly seek to maximize student motivation or engagement by using supplements or alternatives to physical textbooks and face-to-face classroom instruction. These endeavors of organizations and individual instructors can be served well by leveraging opportunities to connect statistical concepts to the world beyond classroom walls. These endeavors can span varied ages (from elementary education through adult education) as well as varied modalities (e.g., podcasts, field trips, museum/library events, radio/TV, songs, culture, virtual worlds, AR, service learning, etc.). We overview varied examples and note potential benefits and next steps for statistics education.

INTRODUCTION

Initiatives such as the International Year of Statistics and recent video contests (sponsored by Statistics2013, Consortium for the Advancement of Undergraduate Statistics Education (CAUSE), and the American Statistical Association (ASA)) reflect increased effort to present statistics to the public as a subject that connects to all areas of life. This creates further opportunities and inspiration to help our students see statistics this way as well. Creating engaging experiences or videos can also be ways to combat the negative image of statistics all too often expressed in the general community (Petty, 2010) and their authenticity is a way to show that “data are not just numbers, they are numbers with a context” (Cobb & Moore, 1997, p. 801).

In informal science education, Braund and Reiss (2006) classify out-of-classroom experiences as occurring in the *actual world* (e.g., field trips), the *presented world* (e.g., museums) or a *virtual world*. This paper aims to compile a representative set of diverse resources and examples of all three types within this framework that statistics instructors can pursue.

SELECTED EXAMPLES FROM THE VIRTUAL WORLD

Statistical sampling and survey techniques can be practiced within Second Life (Bell, Castronova, & Wagner, 2011) and students can also explore the impact of the level of “social presence” in a virtual interview. An example of connection between the virtual and actual world is Augmented Reality (AR) (e.g., Cheng & Tsai, 2013). An example of image-based AR in statistics might be a book’s marker label activating via webcam capture a virtual element “shown upon the book and recovered on the [desktop] computer screen that can be manipulated by tilting or rotating the book” (p. 452). This could be a “beyond the book” way to explore a three-dimensional graph or distribution. Also applicable to statistics is how a location-based AR inquiry-based activity, by superimposing computer-generated information on mobile devices based on position (e.g., GPS) data, can engage students “in scientific thinking (e.g., argumentation or literacy) due to the requirements of assessing evidence, developing hypotheses, testing them against evidence, and finally generating theories” (p. 455).

SELECTED EXAMPLES FROM THE ACTUAL WORLD

Data Collection Field Trips

There are many ways to incorporate data into activities that spill out into the community. Rubel, Chu and Shookhoff (2011) describe a “community walk” in which teams of students and teachers walk through their local census tract with a mathematical or statistical eye, then relating their observations (e.g., about the neighborhood’s workers, residents, challenges, and resources) to data from resources such as <http://factfinder2.census.gov> or <http://epa.gov/myenvironment/>. Other statistical questions may arise spontaneously as students note traffic patterns, stores that sell lottery tickets, etc. Some quantitative questions of interest could be addressed by bringing on the walk devices such as data-loggers, wireless mobile technologies that use GIS technology, etc. Also, any

video footage can be digitized and treated as data (e.g., Rubin, 2007). This overall strategy can be a vehicle to discuss data sharing and privacy issues (e.g., citizen-statistician.org). Finally, Nilsson (2013) discusses the advantages of real-world probability teaching by using “experimentation-based outdoor situations where randomness cannot be regulated by the assumption of an equiprobable underlying sample space.” In another type of “immersion”, Purdue University launches in fall 2014 a learning community project in which 20 sophomores are selected each year to share a dormitory, take core classes as a cohort, and do mentored research.

Culture

One way statistics can go beyond buildings and books is by connecting with real-life culture, a domain that interacts with statistics more often than generally acknowledged (e.g., Lesser, 2010b; courtroom analogy in Lesser et al., 2013). Whether at a family math event or in a regular classroom setting, instructors can make connections between statistics/probability content and the culture of their school or of individual students. For example, students (especially those of Latino/a background) may appreciate how probability questions can be posed in connection with cultural games such as La Lotería (Lesser, 2013c) or Toma Todo (Lesser, 2010a). Many students (especially those from an Abrahamic faith background) may find fascinating the Biblical or Talmudic connections to concepts such as random mechanisms, acceptance rules, and combinatorics (Rabinovitch, 1973) or the first recorded experiment (Daniel 1:1-16).

Sports and Games

An example of engaging teaching beyond the usual classroom is how Robertson and Lesser (2013) demonstrate STEM content using the popular vehicles of skateboarding and music, respectively. This could be done for statistics by using one or more sports as a vehicle. Indeed, there are already textbooks for the first course in statistics that have many sports as a sustained context for all topics (e.g., Tabor & Franklin, 2012; Wiesner, 2013), as well as books focusing on a single sport such as baseball (Albert, 2003; Rothman, 2012). An athlete could discuss with students (either in a classroom or on a playing field) how spending time studying patterns in films and statistical reports meaningfully informs strategy in future games, such as in the popular 2011 movie *Moneyball*. Nate Silver (of fivethirtyeight.com political fame) is expected to make statistics more prominent in sports via his new association with ESPN.

Another beyond-the-classroom connection is exploring commercially-available games with probabilistic component such as blackjack, bridge, poker, backgammon, Monopoly, Yahtzee, Pass the Pigs, and GOLO (Lesser, 2007b). Also, collections of free online games which readily lend themselves to independent or directed collection of data include <http://web.grinnell.edu/individuals/kuipers/stat2labs/Labs.html> and <http://economics-files.ponoma.edu/StatSite/statgame.html>.

Statistics for Engaged Citizenship

Lesser (2007a) describes how social justice examples can provide personally meaningful and potentially transformative opportunities to learn the importance and power of statistics for assessing, understanding, and changing inequities persisting in society at large, and thus learn statistics not just as a producer or consumer, but as an engaged citizen. Websites listed at the end of Lesser (2007a) such as www.gapminder.org are powerful vehicles to do this. Other authors (e.g., Phelps, 2012) describe the potential of service learning to give students experiences that are inherently valuable and also make first-hand connections of statistics content to real contexts.

SELECTED EXAMPLES FROM THE PRESENTED WORLD

Museums and Libraries

North America's major museum devoted to mathematics (National Museum of Mathematics; <http://momath.org>) opened in late 2012 in New York City (Henebry, 2012). The museum is starting to include statistics and probability among its exhibits, such as the *Edge FX* exhibit in which a quincunx interactively explores binomial distributions and when they are approximated well by normal distributions (Ben Levitt, personal communication, October 15,

2013). Science museums also commonly include an exhibit or two related to statistics or probability (e.g., exhibits on throwing a pair of dice at the Exploratorium in San Francisco, CA). The world's first museum devoted exclusively to statistics, Sankhya (The National Museum of Statistics; <http://sankhyamuseum.org>), will open on the University of Hyderabad campus in India.

In addition to displaying exhibits, museum and library educators can be encouraged to use statistics in their work with children outside of school. For example, Kliman, Jaumot-Pascual, and Martin (2013) discuss the example of children ages 8-11 using a sticker to indicate (on a bar graph) the method of transportation they used to reach the library. Beyond identifying characteristics such as mode, the graph is discussed for its relevance to proposed cuts in bus service in the community. And just as many libraries and museums have celebrated mathematics on days such as Pi Day (every March 3/14), there are opportunities to present statistics counterpart celebrations. Examples include the quinquennial World Statistics Day (inaugurated October 20, 2010 by the United Nations Statistics Division), the International Year of Statistics (www.statistics2013.org/), and suggestions in Lesser (2007b, p. 11).

Videos

The well-known use of video to provide self-contained (usually under 10-minutes) tutorials of pieces of content certainly exists for probability and statistics (e.g., www.khanacademy.org/math/probability). Petty (2010) notes that narrated video has the additional benefit of *contiguity*, because students can receive the (auditory) explanation and (visual) demonstration simultaneously without having to shift focus back and forth between words and pictures as they do when everything is on paper. Petty reports her You-Tube video "Understanding the p-value" generated ratings, views and citations that suggest impact well beyond her own students. Videos that provide information (especially related to learning to use technology) that students can view outside of class time free up more of the in-person classroom time for deeper, more active exploring and synthesizing of concepts (Carver, Everson, Kuiper, & Posner, 2013). Other advantages of videos and podcasts (and very useful how-to tips) are offered by Hanson (2013).

There are also many videos that attempt to explore the concepts not with a blackboard or slides but with an on-location authentic context. The first major example was the 1989 series *Against All Odds*, 26 half-hour programs produced by COMAP with funding from Annenberg-CPB (<http://www.learner.org/resources/series65.html>). Recent examples of short videos with a sports context include <http://www.khanacademy.org/partner-content/lebron-asks/v/lebron-asks-about-free-throws-versus-three-pointers> or "Science of NHL Hockey: Statistics & Averages" (www.nbclearn.com/nhl/cuecard/56636; aired 1/25/2012).

As a public engagement project ("Communicating Psychology to the Public through Dance: Dancing Statistics"), the British Psychological Society released in 2013 four five-minute videos (<http://www.youtube.com/user/bpsmediacentre>) of professionally-choreographed modern dancers illustrating correlation, frequency distribution, variance, sampling and standard error. Other examples of video for statistics education or edutainment purposes are amstat.org/youtube, statistics2013.org/2013/05/01/the-pinnacle-the-best-the-top-video-is/, and causeweb.org/resources/fun/.

Besides the ability to go beyond classroom walls, Petty (2010) articulates other benefits of multimedia recordings, including: (1) students can watch them repeatedly (in some cases, saving them from asking instructors to repeat explanations), (2) students have more control over their learning by being able to pause and go back to certain parts, and (3) students can take in an increased amount of information through multiple input channels with independent capacities.

Radio/TV/Podcasts

In mid-September 2011, PBS-affiliate station KCOS-TV began airing a locally-produced children's math/science-oriented educational show *Blast Beyond*, hosted by a TV meteorologist and including a live rock band and on-stage audience of local schoolchildren ages 6-9. After initial airing, each half-hour episode was posted on the station's website, accessible to all. During six (of the 300+) episodes, Lesser presented hands-on mini-lessons and also contributed to parts of the show when he was off-stage (all lyrics, most games, and some banter). One particular lesson (Lesser, 2012) explored polls and gave the first and second graders chances to consider how it

could matter how a survey question is worded, the tone of voice an interviewer uses, the order of questions, and whether an “Other” option is provided. To model how results might be displayed, a bar graph was constructed on the spot from data collected from the students using Post-it Notes (each one representing a student’s answer to the question “Which [of these three choices] is your favorite food?”) to form the bars.

NPR-station KTEP-FM airs a daily 90-second program (“Desert Diary”) on various aspects of the region’s cultural and natural history are supplemented by website resources for each presentation (transcription of that day’s offering, images, references, and some teaching and learning resources). KTEP-FM serves a broadcast area of 2 million people (as does KCOS-TV) and Lesser (2005) is an example of an aired statistics-related script archived on its website. An example of a program devoted exclusively to statistics is the half-hour show “Stats and Stories” launched by two Miami University professors at www.statsandstories.net (ASA, 2013).

Of course, there have also been occasional mainstream “non-educational” movies and episodes of television shows that happen to use or reference statistics. Rodríguez-Muñiz (2010) discusses several examples such as how the Monty Hall problem makes an appearance on the TV show *Numb3rs* (episode 13 of season 1, released in 2005) and in the 2008 film *21*. And the Discovery Channel’s Emmy-nominated series *Mythbusters* implicitly involves hypothesis testing, such as the 11/23/2011 episode exploring strategy for the Monty Hall “pick-a-door” game.

Songs

In educational settings, statistical connections to popular culture can be made using “regular songs” (e.g., Lesser, 2001) or “statistics songs” (e.g., Lesser, 2013b). The biennial fun items contest (“A-mu-sing”) sponsored by CAUSE (Consortium for the Advancement of Undergraduate Statistics Education) yields new fun items that often connect statistics concepts to popular culture. For example, Carly Rae Jepsen’s 2012 #1 hit “Call Me Maybe” (named Song of the Year by MTV, nominated for a Grammy, the year’s best-selling single worldwide, and one of the best-selling digital singles of all time) turned into a song about statistical variation that won a second-place award in the 2013 A-mu-sing contest. The CAUSEweb.org collection (of over 80 songs) also includes “The Gambler”, which connects to the common real-world phenomenon of a lottery. In addition to the song, Lesser (2013a) discusses other methods for increasing lottery literacy, including a video, comic strip, website, and technology explorations. A searchable database of 7000+ STEM songs (Crowther 2012) includes some statistics songs.

POTENTIAL BENEFITS AND FUTURE DIRECTIONS

The educational benefits of out-of-school science contexts identified by Braund and Reiss surely also apply to statistics education: improved development of concepts, extended practical work, motivation, shared responsibility for learning, and access to rare material and ‘big’ science (the latter conjures current focus on how “Big Data” may captivate broad interest in statistics). Such experiences can also support ASA (2010) recommendations to fostering active learning and use real data. Also, out-of-school experiences have potential to improve the quality of in-class experiences. We previously noted how having students have certain experiences outside of class time can free up time for additional material or additional depth during the in-person class time. It is also worth noting, as Robertson and Lesser (2013) do, that being involved in certain outside or outreach endeavors can sharpen the in-class teaching professors do by learning, for example, how better to cultivate interactive engagement (including an opening “hook”) in a lesson, and incorporate questions, make real-world connections, and tailor a lesson to student backgrounds.

Now that a collection of examples is emerging, natural next steps include broadening the collection to be less US-centric, giving implementation guidelines, and collecting data on examples’ effectiveness to motivate learning, improve attitudes, or decrease people’s anxieties towards statistics. As part of a National Science Foundation grant (see Acknowledgment), data collected in fall 2013 from a randomized experiment at a university and a community college (with different and diverse student populations) is being analyzed to see if students exposed to particular “fun” modalities (e.g., cartoons or songs) inserted (à la Garner, 2006) into otherwise conventional short content readings in their course management system will perform better on embedded related exam items, display greater improvement in attitudes towards statistics (as measured by the Survey

of Attitudes Toward Statistics, SATS-36), or greater decrease in statistics anxiety (as measured by the Statistics Anxiety Measure, SAM) over the semester.

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