# STORYTELLING AND TEACHING STATISTICS

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Storytelling as a pedagogy for learning introductory statistics concepts offers exciting opportunities, yet remains unexplored. An experiment was undertaken where three small groups of students participated in a storytelling activity involving the normal and sampling distributions. Data was generated by observing students during the activity and recording their experiences in an interview at the end of the activity. Using case study analysis, findings revealed storytelling can expose shallow learning techniques, while simultaneously helping activate students' higher order thinking skills and deep learning. This suggests storytelling has implications for statistics students' learning. To further investigate these preliminary findings, a new research project will scale up the experimental storytelling activity by implementing it in an introductory statistics course.

INTRODUCTION
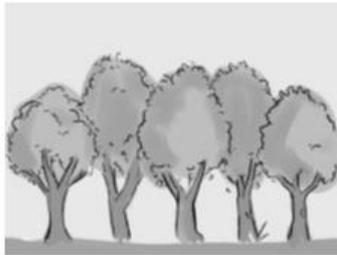
by Sherwood and Greenup

Everyone enjoys a good story. A picture can say a thousand words. So what is the story conveyed by the pictures above? Would individual stories differ based on previous life experiences and depth of thinking? Based on this, what value can be found in adopting storytelling as a pedagogy for teaching first year introductory statistics?

These questions take on increased meaning today with a growing number of first year university students enrolling in STEM courses (Science, Technology, Engineering, and Mathematics). Introductory statistics is one such course where the *hope* is all students will learn a variety of abstract statistical concepts, despite their diverse educational backgrounds, learning abilities, expectations and needs. To address this diversity, researchers such as Cobb (1992) advocated for learning through analysing and making sense of data, while Ben-Zvi & Garfield (2004) investigated statistical literacy, reasoning and thinking. However, the use of storytelling as a pedagogy, to activate students' higher order thinking, creativity, and sense of deep learning has attracted limited research attention. This paper analyses recent case study data where students were tasked with creating a series of linked, contextualized, personally relevant animated stories, using pictures and prose, to communicate their understanding of abstract statistical concepts.

LITERATURE REVIEW

Four key skills considered essential for 21st century graduates are referred to as the 4C's; Creativity, Communication, Critical Reflection and Collaboration. For students studying STEM courses, it is argued integrating the arts will stimulate students' imagination, create open-mindedness, allowing creative talent to emerge to then design engaging solutions to problems (Eisner, 2008). With many STEM courses requiring students to undertake an introductory statistics course, this suggests embedding ideas from the arts into the teaching of introductory statistics to prepare work ready 21st century graduates. Storytelling is one aspect of the arts that has attracted limited interest in statistics education.

For example, during the 1980s, less reliance on pure mathematical approaches arose from student needs to solve real world problems (Moore, 1988). Teachers and students began to adopt clear, understandable layman's language (Boroto and Zahn, 1989). Interestingly, these ideas can be features of storytelling. So too are analogical and representational pictures that have been found to

be useful in conveying abstract concepts (Alesandrini, 1984). Yet during the 1980's, no specific links to storytelling as a pedagogy in teaching first year statistics emerged.

The 1990's saw research shift toward learning outcomes beneficial to students' future careers and attractive to potential employers (Wild, 1994). Teaching approaches saw students learning to construct knowledge using familiar real-world situations and life experiences to make sense of new information (Moore, 1997). Yet during the 1990's, glimpses only of storytelling as a pedagogy are observed. For example, Wild (1994) argued most people like gossip and hearing interesting little stories about the world – a similar theme to the opening line of this paper. However, gossip concerns motivation to learn and no investigation of storytelling into activating the higher order skill of creativity or exploring issues related to deep learning were explored. Similarly, Cobb & Moore (1997) compare data analysis to poetry (a form of storytelling), by recognising the interplay between both context and pattern. Moore (1998) relates learning statistics to learning to perform music, noting technique alone is not enough to become outstanding. Instead, interpretive abilities are just as important to identify and convey the interplay between specific contexts and the underlying story within the music. Yet still no specific research into the value of storytelling as a pedagogy for students learning introductory statistics was undertaken.

During the early 2000s, the emphasis was on *what* (content) and *how* (pedagogy) to teach students (Cobb, 2007). De Veaux & Velleman (2008) argued to help students make sense of abstract statistical concepts, the emphasis needed to be on communication using plain language – key elements to storytelling. Similarly, Clark & Rossiter (2008, p. 62) recognized storytelling helps to make "sense out of chaos" so things "hang together" through creating linkages to experiences. Yet investigating the value of storytelling in relation to allowing students to gain a whole course experience as proposed by Foster & Wild (2010) failed to eventuate. However, Pfannkuch et al. (2010) finally called out this limited research into storytelling for teaching introductory statistics, with Cobb (2015, p. 267) noting context and telling "a story" would see a move away from standard statistics teaching approaches. Phillips (2013) claimed a real lack of appreciation by teachers in how storytelling can help students connect their life experiences to promote new insights, understanding, and meaning-making, has resulted in limited research in the area. Most recently, Noll et al. (2017) identified two story types in their research, being the problem context (the statistical problem as a story) and the students' narrative (their stories). This represented the first real moves to use student narratives to promote their sense-making of statistical concepts. Yet in other disciplines, storytelling as a pedagogy has already taken shape. Free (2004) used storytelling in art classes, with students drawing pictures to then verbally explain factual information. For example, by explaining a hurricane picture, with trees doubled over and sheeting rain lashing the landscape, students found this more tangible than a numerically based written report stating four inches of rain fell with winds of 70 miles/hour.

The literature therefore reveals a gap in understanding how storytelling might support first year statistic students in their learning. However, despite fleeting glimpses, storytelling as a statistics pedagogy remains a vague notion, yet offers exciting opportunities for understanding how it might support student learning. This prompts the research question: How does storytelling allow first year statistics students in a large, university, service course make sense of abstract concepts?

METHOD
The Setting
The research adopted a case analysis methodology, a qualitative research approach. This preliminary study occurred in the School of Economics at the University of Queensland (UQ) at the end of semester 2, 2017. Participants were aged from 18 to 20 and had recently completed a large, first year introductory statistics service course (ECON1310). This course includes topics on descriptive statistics, probability, the normal and sampling distributions, confidence intervals, hypothesis testing, and simple linear regression.

Data Collection and Analysis
Through a process of co-construction, data was generated through communications and interpretations of semi-structured interview material produced between the researcher and participants (Kvale & Brinkmann, 2009). Seven participants were recruited in October 2017

through email invitations and placed into three groups. The groups were given the task of creating two A4 pages of a so called MOSS Book (My Own Statistics Story Book). Each page needed to be 100 to 200 words. The first page focused on the normal distribution and the second the sampling distribution of the mean. In broad terms, each MOSS Book page needed to:

- Capture the key features of the required topic,
- Create and use one single context for both pages,
- Introduce analogical characters to create linkages between both pages.

A time limit of approximately one hour was given to create both MOSS Book pages using only pencil and paper. Participants were then interviewed and asked to reflect on their experiences in creating their MOSS Book pages. Audio recordings throughout were made and later transcribed.

Analysis of the data relied on identifying critical events to develop ideas (Maher & Martino, 1996). These events represent a "significant advance or conceptual leap in previous understanding, thereby helping trace the impact and progressive development of ideas and understanding" (Maher, 2002, p.5). Critical events were identified using sound recordings, observations and reflective diary entries to allow ideas, themes, or theories to emerge (Powell et al., 2003). This allowed previous interviews to inform, shape, and refine subsequent interviews, creating a cycle of data generation. To provide credibility and trustworthiness of the analysis, participants were given opportunities to comment on, clarify, and check interpretations after the analysis of their interviews. Second, peer examination and verification of data generated from participant interviews was undertaken. And third, feedback from colleagues regarding interpretation of the data was sought and acted upon.

INTERVIEWS AND OUTCOMES

Preliminary findings from the three groups' activities and interviews, where participants created their MOSS Book pages for the research project, are presented below.

Interview 1 – Tutors (and their sleepy students)

The first interview (23/10/17) involved two females and one male student. All were experienced tutors in ECON1310, in their fourth year of study, completed ECON1310 in 2014 and received the highest grade of 7. They were explained the requirements of the MOSS Book activity, emphasising the need to use stories, a single context and imaginative characters. During the activity, the group created the following paragraph for the normal distribution:

President John, of the UQ Student Union, is concerned about student welfare and whether students are getting enough sleep. Australian government guidelines states that young adults below the age of 30 require at least 8 hours of sleep to ensure proper cognitive function. John surveys all UQ students by putting a questionnaire in the election forms and assumes all student respond. He then constructs a normal distribution of all the UQ students surveyed based on time spent in bed per day.

Being fourth year, high achieving economics students, the group's first MOSS Book page reflects the use of various academic words such as welfare, government guidelines, and cognitive function. Despite being clearly encouraged to use creative language and imaginative characters, the group worked in a zone where they felt comfortable. It was clear they had been well educated in the world of economic thinking, yet somewhat hesitant to move into the imaginative space MOSS Book had offered. This was also reflected in the limited time devoted to the central idea of creating analogical characters for both MOSS Book pages. Stick figures, rather than imaginative characters, were used to represent a student. This meant no clear connections between context, stories, characters, and statistical concepts became evident in their two MOSS Book pages. At the end of the exercise, when asked why they were not more creative or imaginative, the group conveyed a sense that the MOSS Book activity was a bit childish, or "kids stuff". When probed further, this attitude was considered a cultural problem since statistics is expected to about learning mathematics (not kid's stories). Yet on reflection, these high performing students soon recognised they had previously adopted rote learning strategies in studying ECON1310 and as tutors. Their attitude had surprisingly shifted to now appreciating the substiles of storytelling and looking to embrace it: "stories are more about showing knowledge than just replicating what had been shown

in lectures". They now recognised storytelling was not beneath them. Rather, they revealed it as empowering them to now create pathways for knowing, connecting, and applying statistical concepts in practice.

Interview 2 – PASS Leaders (squirrels and nuts)

The second interview (24/10/17) involved two female third year students. They were both peer leaders for the last two years in ECON1310, having completed the course in 2015, with both receiving the highest grade of 7. They completed the same task as students in Interview 1 with one key change. Namely, both MOSS Book pages were now required to use a single context, storyline and characters that a six to seven year old child could understand. Further, the use of mathematical equations and statistical terminology were prohibited. Excerpts of the group's MOSS Book for the normal and sampling distribution revealed the following:

Normal Distribution: *Squirrels love eating nuts. Because of their love for nuts, they often stash nuts for winter. Each squirrel has its own special hole in its tree where it can safely stash its nuts. Nuts come in all shapes and sizes. Some are big and some are small. But most nuts are medium size.....*

Sampling Distribution*: Some squirrels work really hard and fill their trees full of nuts. Others are lazy and sleep most of the day so they do not have many nuts in their tree..... In the local town lives a man (a hillbilly dude!) who sells nuts at the market. He is very lazy and instead of collecting his own nuts, he steals them from the poor squirrels.....*

In specifying the new child-like language requirement for the MOSS Book activity, an immediate impact become apparent. Imaginative characters and a creative context clearly emerged, with simplified, non-academic language adopted compared to Interview 1. Yet despite the minor rule changes making the creative task seemingly easier, the group soon discovered the challenge it posed in being able to find the words to communicate statistical ideas simply. To do so, they revealed at the end of the MOSS Book activity how this challenged their usual way of thinking, and like students in Interview 1, found they were outside their usual academic comfort zone. They claimed to be naturally uncreative, offering what seemed to be an excuse by claiming "people who do economics and statistics are not very creative at all". Yet clearly both MOSS Book excerpts above reveal creative potential. Subsequently, they realised that given the right learning environment and opportunities, their untapped creative potential could help them learn to think and so understand the basics of statistics to then explain complex ideas simply.

Interview 3 – Recent Students (family of bears)

The third interview (1/11/17) involved two female first year international students, with good English language skills, who completed ECON1310 in semester 1, 2017. Both received the highest grade of 7. They completed the identical tasks to those in Interview 2. However, in Interview 3, the group's experiences followed three distinct phases – mental anguish, realisation and discovery.

Mental anguish revealed itself early. Being friends from high school, they relied on a familiar example encountered as class-mates about student heights being normally distributed. They agreed to use bears and weight (rather than students and height) after about five minutes into the activity. However, frustration soon set in when they struggled to translate ideas from student height to bear weight: "I don't know how to tell the story using weight". This was compounded by battling to translate statistical terminology into understandable childlike language. One complained six times how hard the task was. In both MOSS Book pages, neither story flowed nor came easily. As their frustrations grew, they repeatedly checked their understanding with each other.

After about 20 minutes of working on their MOSS Book, a realisation phase shocked them into seeing how little they knew about the normal distribution. Initially deciding to draw a family portrait of bears to represent the normal distribution, both later realised they had missed the point. Yet despite sensing something was not right during the activity, they continued on, fixed to their example from high school and trying to make sense of things. The side calculations on their MOSS

Book page for the normal distribution involving weights of baby, mama, and papa bears, shown in Figure 1, captures their frustrations in trying to work backwards to generate their story.
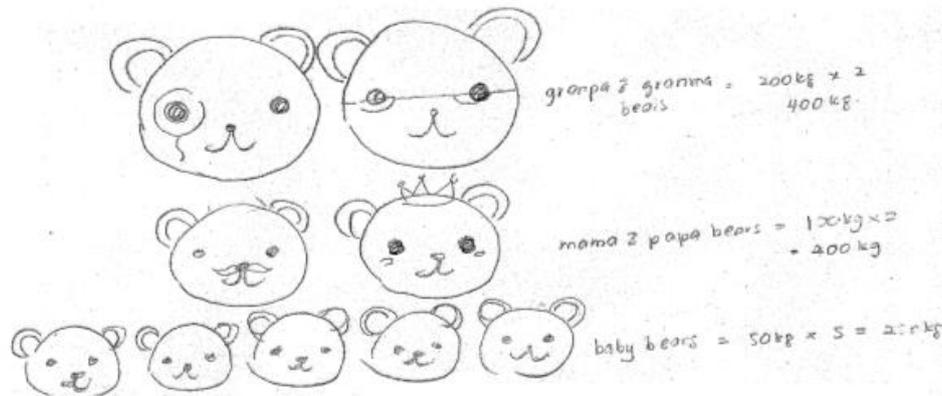

Figure 1. MOSS Book excerpt from Interview 3.

Both students lastly encountered a discovery phase, one that revealed how their learning was based around "getting a good mark" by memorising rather than understanding. They described learning statistics as being "black or white", right or wrong. They discovered this attitude resulted in shallow learning approaches. It revealed to them why they found it "difficult to explain what I understand" to friends when asked "tell me what you understand". They concluded by stating their learning would make more sense if they were able to write down their "own story". Surprisingly, they decided to try adopting the activity ideas for their courses next year, suggesting they would feel better about their learning and then trying to explain concepts to friends using stories.

CONCLUSIONS

In summary, looking back over the last 40 years, limited research has been devoted to storytelling as a pedagogy in teaching introductory statistics. Preliminary findings in this paper provide insights into the research question as to how storytelling allows students to make sense of abstract statistical concepts. This is revealed through considering students' learning experiences.

First, by requiring students to explain abstract concepts simply, their experiences bring to light their realisation of not knowing what they thought they knew. In their attempts to create a single context, with characters and storylines linking different statistical concepts, they display frustration, struggling to break down the abstract into something simple. This then allows them to progress to a second stage where they appreciate their lack of in-depth understanding of concepts and the rote learning strategies they had adopted. By then reflecting on storytelling as a way of supporting their learning, they progress to a third stage. Here they see their experiences of creating personal linkages between abstract concepts using a single context, along with their own story characters, as helping them make sense to things and so operationalising deep learning. In other words, by providing safe environments and opportunities for storytelling as a pedagogy, students' higher order thinking skill of creativity can be activated. In essence, storytelling seemingly allows students to move from a state of I think I know, to the realisation of I don't know, to ultimately finding a way of knowing.

The implications of these preliminary findings suggest exciting opportunities exist for further investigating how storytelling allows first year university statistics students in large, service courses to make sense of abstract statistical concepts. During 2018, over 800 ECON1310 students are expected to complete the MOSS Book activity as an assessable learning activity. Looking forward, this should provide further insights that hopefully capture the vision for storytelling in teaching statistics intended to be conveyed in the three sketches at the start of this paper. Namely, the forest may look strong and healthy (current learning approaches), yet intervening stormy conditions can expose weaknesses (introduce storytelling for learning), thereby allowing regrowth of new trees in a changed environment (operationalise higher order thinking skills and creativity).

REFERENCES

Alesandrini, K. L. (1984). Pictures and adult learning. *Instructional Science, 13*(1), 63-77.

Ben-Zvi, D., & Garfield, J. B. (2004). The challenge of developing statistical literacy, reasoning and thinking: Springer.

Boroto, D. R., & Zahn, D. A. (1989). Promoting statistics: on becoming valued and utilized. *The American Statistician, 43*(2), 71-72.

Clark, M. C., & Rossiter, M. (2008). Narrative learning in adulthood. *New directions for adult and continuing education, 2008*(119), 61-70.

Cobb, G. (1992). Teaching statistics. *In Heeding the Call for Change: Suggestions for Curricular Action*, Ed. L. A. Steen, 3-43. Washington, D.C.: Mathematical Association of America.

Cobb, G. W. (2007). The introductory statistics course: a Ptolemaic curriculum? *Technology Innovations in Statistics Education, 1*(1).

Cobb, G. W. (2015). Mere renovation is too little too late: We need to rethink our undergraduate curriculum from the ground up. *The American Statistician*, *69*(4), 266-282.

Cobb, G. W., & Moore, D. S. (1997). Mathematics, Statistics, and Teaching. *The American Mathematical Monthly, 104*(9), 801-823.

De Veaux, R., & Velleman, P. (2008). Math is music; statistics is literature (or, why are there no six-year-old novelists?). *Amstat News, 375*, 54-58.

Eisner, E. (2008). Art and knowledge. In J. G. Knowles & A. L. Cole (Eds.). Handbook of the arts in qualitative research. Thousand Oaks, California: Sage.

Forster, M., & Wild, C.J. (2010). Writing about findings: Integrating teaching and assessment. In P. Bidgood, N. Hunt, F. Jolliffe (Eds.), *Variety in Statistics Assessment.* New York: Wiley-Blackwell.

Free, W. P. (2004). Pictures and words together: Using illustration analysis and reader-generated drawing to improve reading comprehension. Ph.D theses. ProQuest Information and Learning Company.

Kvale, S., & Brinkmann, S. (2009). Learning the craft of qualitative research interviewing. Thousands Oaks: Sage Publications.

Maher, C. A., & Martino, A. M. (1996). The development of the idea of mathematical proof: A 5-year case study. *Journal for research in Mathematics Education*, *27*(2), 194-214.

Maher, C. A. (2002). How Students Structure Their Own Investigations and Educate Us: What We've Learned from a Fourteen Year Study. *In 2002 Proceedings of the Annual Meeting of the International Group* for the Psychology of Mathematics Education.

Moore, D. S. (1988). Should Mathematicians Teach Statistics? *College Mathematics Journal, 19*(1), 3-7.

Moore, D. S. (1997). New pedagogy and new content: The case of statistics. *International Statistical Review, 65*(2), 123-137.

Moore, D. S. (1998). Statistics among the liberal arts. *Journal of the American Statistical Association, 93*(444), 1253-1259.

Noll, J., Clement, K., Dolor, J., & Petersen, M. (2017). Students' use of Narrative when constructing statistical models in TinkerPlots. *10th Internal Forum for Statistical Reasoning, Thinking and Literacy*, New Zealand.

Pfannkuch, M., Regan, M., Wild, C., & Horton, N. J. (2010). Telling data stories: Essential dialogues for comparative reasoning. *Journal of Statistics Education, 18*(1), 1-38.

Phillips, L. (2013). Storytelling as pedagogy. *Literacy Learning: The Middle Years, 21*(2), ii.

Powell, A. B., Francisco, J. M., & Maher, C. A. (2003). An analytical model for studying the development of learners' mathematical ideas and reasoning using videotape data. *The journal of mathematical behavior, 22*(4), 405-435.

Wild, C. J. (1994). Embracing the "wider view" of statistics. *The American Statistician, 48*(2), 163-171.