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Statistical Thinking and Future Thinking

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STATISTICAL THINKING AND FUTURE THINKING AS PREPARATION FOR ENGAGEMENT IN THE GLOBAL COMMUNITY

ABSTRACT

Business Statistics is one of several courses students in our business school are required to take. It is also one of the courses students have difficulty in performing well. The real benefit of exposure to statistics is not just mathematical understanding, however, but the development of an ability to think conceptually and to think about the future. These perspectives are invaluable preparation for engagement in a global community. This ability has been referred to as "Future Thinking," (Claiborne, 2014). Future Thinking is, at its core, probabilistic and also empathetic. Those high in future thinking can envision a future with its given possibilities and chart a course of action with a "feeling" for interactions yet to come. In this paper, we examine how an understanding of the concepts of statistics can enhance the ability to think about the future.

Keywords: *business statistics, statistical thinking, future thinking.*

1. INTRODUCTION

Business statistics is one of the quantitative courses whose underlying concept students have difficulty in understanding. This should not happen because the course is taught after college algebra and, in many cases, after or concurrently with calculus. Watts's (1996, p.290) assertion that "Introductory statistics courses involve concepts that are more abstract …" than those covered in calculus, is not a justification for poor understanding. The abstract nature of the concepts should be considered a reason for, not limitation of the course. We think framing the course with regard to the ability to think abstractly will supply a context more in line with some of the real take-aways from the statistics course. The ultimate goal of the course is conversancy with this kind of abstract thinking, rather than the manipulation of formulas. A major factor that also contributes to the difficulty in the course is the lack of mastery of the basic mathematical concepts (Hotelling, 1947; Pappanastos et al., 2002; Pinney and Jaska. 1992; Woldie et al., 2002). Mathematical language is metaphorical, however. We need to be mindful of what was suggested by Brown and Kass (2009, p.107), that "… statistical training … should be to help students develop statistical thinking". "Statistical thinking," refers to a view of systematic connections and interrelations. Means, variances and effect sizes all relate to each other and to a system of understanding.

Arguably education is for, if not about, the future. At every level, education seeks to prepare participants for what comes next. We believe that a particular type of thinking informs this basic goal, no matter whether the discipline be professional or scientific. Future Thinking, the ability to envision alternatives, and assess the feasibility of each alternative is inherent in planning and research analysis. It is our belief that education has the obligation to produce students that can think and plan for the kind of contingent and diverse futures likely to be experienced by a global community.

The term future thinking is conceptually rooted in cognitive and developmental psychology. Atance and O'Neill (2001), drawing on Tulving's concept of episodic memory (1984), defined a more specific type of self-projection in which a future state is "pre-experienced." In future thinking, however, the imagination is usually constrained to specific sequences, for example: thinking about a future vacation requires consideration of what work must be complete before going, how much spending money will be needed, etc. Future thinking embodies prospective memory (planning and remembering to execute the plan), judgement and decision making (for example considering constraints), goal attainment (implementation intentions or commitment) and future time perspective (the extent to which future potentially distant outcomes influence current behaviors). Developmentally, future thinking starts to appear about age 3 when children's talk includes an understanding that the future is not merely a recapitulation of the past.

Children can choose a larger delayed reward by age four. It is not until age 4 to 5 that children exhibit more sophisticated planning and anticipatory behaviors.

Future thinking has been analyzed in terms of temporal focus, approach vs. avoidance of positive and negative outcomes, proximal and distal goal setting, the ability to disengage from the immediate environment, the capacity to envision, the ability to consider the potential consequences of action, the capability to override current needs in favor of longer term goals and the ability to mentally pre-experience an event. It has also been linked to episodic memory. It is believed that episodic memory and future thinking emerge developmentally at about the same time (Atance and Metoff, 2005). Future thinking is also related to the ability to remember past events, what has been called autobiographical memory. Memories and imagining both involve a kind of mental time travel to construct or reconstruct episodes. It is this episodic memory capacity, that is critical to future thinking for it allows us to imagine a possible (otherwise non existing) future (Berntsen and Bohn, 2010). Although some are more adept at future thinking, as with remembering, it is an ability that can and should be developed more and therefore should receive more attention in our curricula.

2. THE CONCEPTS AND PROCESSES OF STATISTICAL THINKING

Business statistics courses typically cover descriptive statistics with graphical and numerical summary measures, basic probability, probability distributions with applications, sampling techniques, sampling distributions, parameter estimation (point and interval), hypothesis testing (one sample, two sample and multi-sample problems), model building (simple and multiple regression), analysis of frequencies, time series and non-parametric methods.

Interval estimation and hypothesis testing follow and then the interpretation of such estimates. The connection between confidence intervals and hypothesis testing, is covered, pointing out the similarities and differences between one sample, two sample and multi-sample problems. Model building, sometimes a baffling topic follows. Understanding the meaning of the parameters, finding their estimators, interpreting their numerical values and graphical representation of these results are just some of the challenges.

We all use probability concepts, in making decisions subjectively, in our daily life i.e. deciding what to wear on a given day (if it is rainy, sunny or foggy etc.), what route to take to go to work or come back home. Therefore “statistics” is more than the simple tally we hear on a radio or see on a television sports channel. The word “statistic” may seem the singular of “statistics” (Iman and Conover, 1989). Our daily usage of the word “population” implies a different meaning than how it is used in the field of statistics. Testing results indicated that less than half of those taking statistics courses write correct definitions of these terms or phrases. A clear understanding of words or phrases like these is extremely important to help appreciate basic concepts of statistical inference and data analysis.

Statistical symbols complicate things even more. Symbols, such as σ2, and ρ are used to represent parameters. For sample measures we use symbols like S, S2, r and S. Each symbol has its own formula. In these formulas the expressions that are common include ∑x, ∑x2 and (∑x)2. Although, these and other formulas are gradually introduced, manipulating them i.e. substituting numbers in these formulas and simplifying them is a challenge to some students.

Furthermore, when evaluating one of the above parameters and the corresponding statistics, it is easy to get intimidated by formulas. A more historical view of statistical terms can help understanding and aid in applying statistical concepts to future thinking.

3. MASTERING THE LANGUAGE OF STATISTICS WITH AN EYE TOWARDS FUTURE THINKING

In the 1660s the systematic study of social numbers was presented as “political arithmetic” (Graunt, 1676). Its professed purpose was the promotion of sound political policy. Later William Petty (1691) sought to bring “perplex matters to terms of numbers.” By 1894 statistical measurements had come to be considered “social facts,” (Durkheim, 1894). Phillips (1973) proposed a structural approach to statistical thinking where all measurements are considered in relationship to other measures obtained in a similar way.

More recently the discipline has sought to differentiate statistical literacy, mere knowledge of the terms, from statistical thinking. Statistical thinking is defined as questioning the issues and data involved. Building on this approach there has been an increasingly strong call to focus not on methods or results, but on how to interpret what is found.

Although statistics uses mathematics and probability, as pointed out above, the field did not originate with mathematics, but rather as a logical and empirical science. Averages were viewed as the stable part of noisy processes, not just means. Variation was a basis for assigning cause which leads to the discussion of variability. Terms like average and variability, take on accentuated meaning when talking about the future.

4. STATISTICAL THINKING AND FUTURE THINKING

Future thinking isn’t just about the future, however. The implicit self-narrative in future stories relates to individual difference characteristics such as self-efficacy and self-image congruity. Self-efficacy (Bandura, 1977), is the extent that one believes in their ability to complete tasks, reach goals and control their own destiny. Level of self-efficacy relates to how difficult a task one is willing to take on and how long they will stick with it. People who believe that they have more control of their lives are more willing to think about the future. Conversely, those with a greater ability to imagine the future envision more positive than negative possible outcomes. This is also related to Self-congruity theory (Sirgy, 1982), the idea that I see myself in comparison to some ideal other. A future self can be defined in comparison to an ideal self of the future. Those with greater ability to imagine a future self are more likely to do things in the present to move toward that ideal future self. Future thinking therefore has the potential to promote subjective well-being (Diner, Suh, Lucas and Smith, 1999) by virtue of promoting more positive thought about the future, the feeling that there is more ability to control the future and by having a more crystalized image of an ideal self in the future.

5. APPLYING STATISTICAL THINKING

It is extremely important to put emphasis on the logical connotations of statistical terms. These terms, that characterize statistical thinking, add to our ability to develop and analyze scenarios created in future thinking. Most often scenarios are developed based on qualitative analysis. Statistical concepts allow for the inclusion on quantitative “facts” to enhance thinking about the future (see Table 1). Four primary concepts have been used in developing scenarios: they are driving forces, what is of greatest importance in the scenario; uncertainties, what is most fearful; certainties, what is most likely and triggering events, seed change moments. These are often arrayed to tell a story about the future. These stories are not extensions of present conditions or extrapolations but rather possibilities (See Claiborne, 2014 for an example of scenario development). With the addition of statistical thinking concepts we can now add quantitative information to enhance scenario development. We now can look for statistical concepts stemming from structural comparisons like effect sizes which indicate the relative importance of “social facts.” Uncertainty can now be defined by variation. If I am a retailer and the biggest fear I have, the biggest uncertainty, is a competitor establishing a web presence that can be unpacked by perhaps looking at variations in sales of brick and mortar business with online competitors. The parameters of the uncertainty can now be defined for the scenario. Certainties can be defined in terms of means. Means are not just averages but can be seen as stabilizing forces. Finally, triggering events, the most difficult concepts to account for in scenarios, can be seen, using statistical thinking, as outliers. Outliers discovered in research could eventually provide the type of seed change that must be accounted for in “wildcard” scenarios.

TABLE 1. A COMPARISON OF FUTURE THINKING CONCEPTS AND STATISTICAL THINKING COUNTERPARTS

Future Thinking	Statistical Thinking
Driving Force - what is of greatest importance. What propels the scenario forward	**Effect Size -** a comparative statistic that give the relative importance of each "social fact"
Uncertainty - what is most fearful. The least desirable option.	**Variation** - fluctuation. unstable results.
Certainty - what is most likely. Outcomes that are already in the pipeline, although the timing is uncertain.	**Mean** - a stabilizing force.
Triggering Event - a event that changes what comes after it.	**Outlier** - observances numerically distant from others that portend a change of state.

Applying statistical thinking to future thinking and scenario development better enables us to encounter a global environment with more variables and more options that must be addressed. Business people will be more competent to engage the global community with these tools in their arsenal.

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