STATISTICS *IS* A LIBERAL ARTS MAJOR

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A liberal arts education transcends any particular major, preparing engaged citizens ready to serve as future leaders of a free people. Specific definitions of "The Liberal Arts" vary from evoking classical disciplines to exploring the human condition, from focusing on simple breadth, to developing skills in communication, critical thinking, and unstructured problem solving. As opportunities grow, many new statistics majors emerge from pre-professional programs in computer science, medicine, engineering, or business programs. A well-crafted statistics major exemplifies the liberal arts, regardless of one's definition, while preparing students for success in technical fields, leadership in business and industry, and graduate/professional study. Such a major requires students to intentionally develop skills through activities and projects embedded in statistics courses, evolving beyond standard mathematics, coding, and statistical analysis.

BACKGROUND

The debate over the value of higher education began in classical antiquity, continued through African-American educators W.E.B. Dubois and Booker T. Washington at the turn of the last century, and shows no sign of ending (Hart Research 2013 and Sandeen 2013). This debate can be summarized as an argument between those who think that the purpose of college is preparing for a successful career and financial success (Waechter 2015) and those who believe that higher education should prepare graduates to deal with complexity, diversity, and change as citizens and leaders (AACU 2007). The liberal arts is about both the search for truth, and the responsibility to act according to that truth. As Weisbuch (2016) states:

> *"Although one obligation of a liberal education (not the opposite of 'conservative,' but Cicero's term for an education befitting a free citizenry) is to scout honestly all positions, another is to reach a conclusion and act without compromise upon it. That conclusion may be one of the considered positions, an amalgam of them or a fresh alternative -- just as long as it is earned." (2016)*

Statistics as a formal discipline, separate from mathematics or applied areas like demographics, psychometrics or biometrics, is relatively new, with the first Statistics Department in the world founded by Karl Pearson at University College, London in 1911 (UCLondon 2017), arriving in the United States and India in the 1930s (David 1998). Statistics programs live within schools and departments across many corners of campuses, from Mathematics and Engineering to Agriculture, Psychology and Business (David 1998). In the twenty-first century, the number of awarded statistics degrees has seen a sharp increase (Pierson, 2014). However, programs and departments awarding these degrees continue to live in disparate places at different schools. Although statistics programs may be placed in a number of divisional "homes," including some that are not likely to be associated with the liberal arts (engineering, medicine, applied health, and business, among others), statistics is not only consistent with the vision of a liberal arts education, but might serve as the exemplar of a modern liberal arts major.

In some countries, statistics education reform is embedded within broader mathematics education reform (Woo 2000). Even in parts of the world where university programs do not include many general requirements outside of a major (Europe and India in particular), but are instead covered in pre-University programs (like the German Gymnasium), thinking about the connections between statistics and the liberal arts may be useful.

A well-constructed statistics major can be justified as meeting the criteria for a liberal arts major under any of the four following definitions. After discussing each definition individually, we will list the "union" of components necessary for a liberal arts statistics major.

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CLASSICAL DISCIPLINES

Students should study a traditional list of Arts and Sciences, growing out of classical Trivium and Quadrivium (Table 1), but now thought to include history, literature, philosophy, mathematics, etc. Additionally, any major must include sufficient material from these areas (AACU 2017, PBK 2017), and the traditional activities of those disciplines - reading, writing, and research.

Trivium: Arts	
Logic	The art of thinking
Grammar	The art of inventing and combining symbols
Rhetoric	The art of communication
Quadrivium: Sciences	
Arithmetic	The theory of [discrete] number
Music	Application of the theory of [discrete] number
Geometry	The theory of [continuous] space
Astronomy	Application of the theory of [continuous] space

Table 1. Trivium and Quadrivium (as summarized in Joseph and McGlinn, 2002, p3).

The seven classical disciplines were present in classical Greek thought as early as Plato and Pythagoras, but gained prominence as an educational framework in the 5th century AD (Joseph and McGlinn, 2002), and continued through the Renaissance as the hallmarks of a meaningful education (AAC&U, 2015).

The Trivium is concerned with the mind, and how ideas are organized. Statistics, especially when combined with ideas of probability, deal substantively with the interaction of deductive (proof-based) logic and inductive (evidence-based) reason. Statistics blends logical thinking and objective evidence to understand relationships (Ehwa University web page). Rhetoric is embedded in statistics, taking the results of formulas and returning immediately to the practical decision at hand, with a focus to convince others (even those without statistical training) of the wisdom of making that decision. Grammar, broadly defined as the study of systemic rules for the movement from a symbolic form to a practical form (and back) is a necessary skill for any statistician.

The Quadrivium studies two dichotomies, the relationship between the continuous and the discrete, and the relationship between the theory of matter and its reality. Within the classical system, as listed here, music and astronomy might not actually involve playing a musical instrument or looking at the sky, but rather learning about the mathematical framework of ratios (for music) or the building blocks of trigonometry (for astronomy) that underlie those areas (Joseph and McGlinn, 2002). Even an introductory statistics class deals with both of these issues, moving from the discrete distributions (e.g. Binomial) to the continuous (e.g. Normal), while simultaneously moving from probability into inference to explore how theory becomes application.

In modern times, the liberal arts disciplines continue to be valued, even as the topics themselves have been embedded in a variety of areas. A well-planned statistics major addresses all seven of the classical disciplines, both within individual statistics courses and across general education courses offered by the university.

BIG IDEAS

"Beyond preparing students for a single "vocation," students should focus on the illumination of the human condition and the meaning of life." (PBK)

On their page about starting a new chapter, Phi Beta Kappa, the United States' oldest and most prestigious liberal arts honor society, says this:

> *"...students are engaged in study that illuminates the human condition by exploring aspects of taste and feeling, of the reasoning process, of the physical and moral worlds, of individual and group responsibility, and of the meaning of*

> *life as a whole. The study of literature, languages, philosophy, religion, the fine arts, history, the social sciences, mathematics and the natural sciences is held to be central to the objectives of Phi Beta Kappa." (2014)*

Phi Beta Kappa specifically excludes credits earned from "vocational" areas, such as engineering and business, for those being considered for membership, while valuing those areas that may not lead directly to specific careers, such as history, literature, mathematics, and philosophy.

Statistics may lead to a lucrative career, and often relates to those vocational areas, but at its heart, the field of statistics is intricately tied to illumination of the meaning of life. For a century, the field of statistics has had a tension between those interested only in abstract theory, those interested in "vocational" application, and those who are interesting in applying statistics for the good of humanity (Salsburg, 2001). Statistics moves beyond vocational training into the study of the human condition, as described by Phi Beta Kappa.

Statistics certainly should explore issues of individual and group responsibility. Ethical failures by researchers using statistics are easy to identify using a simple Wikipedia search, (e.g., Tuskegee Syphilis Experiment, Nazi Experimentation, or Eugenics). These failures were important enough to include in the Nuremberg code, later codified into the Geneva Convention and subsequent international treaties. Interestingly, almost none of these failures are a result of statistics itself, but rather are due to an inability to see beyond the experiment, and a refusal to engage in broader discussions about meaning and humanity.

Today, questions of privacy, consent, and how local decisions have global impact are among what an educated citizen needs to understand in order to join the debate. Statistics is central to these important discussions, and statisticians need to be ready to be part of the discussion. Statisticians could be leading the discussion of some big questions, such as "Who owns your data?" or "Can algorithms be biased?". A well-designed statistics major must prepare graduates to be such a citizen, and to be able to help those without formal statistical training to make wise decisions, personally and collectively.

BROAD EDUCATION

> *"Students should take much of their coursework outside of their major field of study, and find ways to connect that outside knowledge to the "Big Ideas" of their major and those of society." (AAC&U 2007)*

The field of statistics has also seen division, like much of science, between those who are working on small problems only applicable to specific subfields, and those who try to look across disciplinary areas to see how the methods of one discipline can be used in others. Techniques such the split-plot design, Mann-Whitney-Wilcoxon rank sum test, and factor analysis were developed multiple times by statisticians working in various disciplines, or found wide acceptance in one field before being applied to others (Salzburg).

This tendency to miss the big picture is regretted in a popular meme of one of the giants of statistics, R.A. Fisher, putting himself clearly on the side of the liberal arts. "The tendency of modern scientific teaching is to neglect the great books, to lay far too much stress upon relatively unimportant modern work, and to present masses of detail of doubtful truth and questionable weight in such a way as to obscure principles." (Meme accessed from https://goo.gl/images/sCZz43 , quote originally in Fisher and Stock, 1915.)

Outside of Europe and India (which typically focus more heavily on a student's major program), colleges and universities in the United States, South Korea, and have long focused on requiring students to take substantial coursework beyond a major. Many non-vocational fields at US institutions require at least half of the credits to be taken outside of one's major. While degree expectations outside of the United States vary, in recent years, universities in the UK have started requiring additional breadth (Atwood 2010). One Korean blogger argues that this breadth is a strength and cause of Korea's economic expansion (Liberal Ed. and Coffee 2012).

Regardless of university requirements, it is unlikely that any statistics major would not include coursework in mathematics and computer science, as well as courses in the social and/or natural science. Students should be able to apply statistical reasoning to domain-specific questions

(AmStat 2017). Discipline-specific knowledge, such as agriculture, biology, psychology, business, health, or engineering is crucial, with a preference for room to explore multiple fields of study. Statistics began as the "study of the state" and grew in importance as agriculture, psychology, and genetics grew into mature sciences at the beginning of the 20th century (Salsburg 2001).

A well-designed statistics major should also expect multiple opportunities for deep connection to communication AND ethical reasoning. Beyond strict breadth or depth in a statistically-driven disciplinary field, statistics courses should include connections, embedding ethics discussions content-rich methods and theoretical statistics courses to see how the practice of statistics relates to real world problems. Good communication and working as part of a team are necessities for any modern statistical analyst, and writing, speaking, and teamwork should be embedded across the statistics curriculum.

Statistics is a key part of bigger discussions, and we must make sure students are aware of these "big ideas." These may include questions like:

- How are statistical assumptions crucial to scientific consensus about climate change?
- How can data be used to develop models for disease?
- How are the now-discredited ideas of Eugenics still influencing discussions a century later?
- Can the "Green Revolution" continue indefinitely to feed a growing world population? (Should we still consider Malthusian ideas of a maximum human capacity of our planet?)

LIBERAL LEARNING

"Focuses on broad learning objectives beyond a disciplinary perspective, such as critical thinking, communication skills (speaking, writing, etc.), and problem solving, to create an educated person prepared to be an active citizen leader in a free society." (AAC&U 2007, Roche 2010)

Undergraduate statistics programs often already contain many of the liberal arts components listed as "Essential Learning Outcomes" in the AAC&U 2007 report. These include a broad knowledge of culture and the physical and natural world and integration across fields to look at big questions (as in definition 3), as well as intellectual and practical skills like communication, quantitative and information literacy, teamwork, and problem-solving skills, and ethical reason and social responsibility. Most statistics curricula already incorporate intellectual and practical skills, personal and social responsibility and integrative learning. Statistics courses often practice critical thinking and communication skill. Statistical literacy has been shown to be a key outcome for a basic statistics course (Gal 2002) and is central to a modern statistics major (Ridgway 2017), so we must build these into upper-level undergraduate coursework. Statistical understanding is valuable in everyday life and the foundation in understanding new information throughout one's lifetime (ASA 2014). International datasets and educational resources like http://gapminder.org (founded by Swedish statistics "Rock Star" Hans Rosling) and http://www.ProCivicStat.org/ (multiple European and Israeli Universities funded by the European Commission) show that these ideas are indeed already global and spreading.

A well-crafted statistics program will enhance many, if not all, of these liberal arts elements. A liberal-arts version of a general education curriculum emphasizes the study of as many liberal-arts related areas as possible. This will be particularly beneficial to statistics students' understanding of the content in the projects from various different disciplines. Well-designed statistics courses emphasize not only inquiry, analysis, and critical thinking but the importance of teamwork and communication through frequent projects. More statistics programs are requiring or recommending real life projects that can affect the local and global community. Ethical issues are always very important in statistics especially in studies involving living subjects. Liberal arts education emphasizes broad knowledge and thinking, problem solving, and communication skills thus it benefits statistics students to understand the need of the community and ethical issues the project may encounter. A good statistical analysis synthesizes the results in the area of study and find the meaning and general implication of the findings.

TAKEAWAYS

Looking across the four definitions, many components of the liberal arts are inherent to a statistics major, requiring no additional effort. Logic, the interaction of the discrete and the

continuous, the theoretical and the applied, quantitative and information literacy would be hard to prune from a statistics curriculum.

All four definitions point to coursework outside of the major and connections from courses inside the major to ideas beyond mere technical competence. The 2014 ASA curriculum guidelines suggest (p. 10) that this can be done by requiring coursework outside of the major, or by requiring students to choose a second major or a minor. Keeping a statistics major small enough to allow electives might be a natural way to allow undergraduates to make their own decisions about possible directions, when mentors and advisors are available for support. Designing mid-level statistics courses to be accessible and desirable by students in statistically-driven majors such as business, psychology, and health may increase the opportunities for meaningful discussion, and different viewpoints when "Big Ideas" are considered. Upper-level and capstone courses can be designed to explore open-ended project topics, requiring not just good statistics, but logical reasoning and communication skills.

A modern statistics major (Cobb 2015) that builds on ideas of statistical literacy (Ridgeway 2017) and Civic Engagement (Engel 2015), embraces real data sets of sufficient size and importance (Rosling 2005) will most definitely clearly be a liberal arts major. We close with several questions that new programs and those looking to embrace liberal thinking might consider:

- Does mathematical theory and coding content relate to statistical ideas?
- Are statistics students getting sufficient chances to write, speak, and work in teams?
- Is ethics incorporated multiple times into both lower and upper level statistical coursework, dealing specifically with statistics and data-related issues?
- Within courses, do we have a chance move away from techniques, computer packages, and data sets to look at the larger picture, including recurring discussion of "Big Ideas?"

With thoughtfully-designed answers to questions like these, it becomes clear that Statistics IS a liberal arts major.

REFERENCES

American Association of Colleges & Universities (AAC&U). (2007). College learning for the new global century: a report from the National Leadership Council for Liberal Education & America's Promise (LEAP). Retrieved from *https://www.aacu.org/sites/default/files/files/LEAP/GlobalCentury_final.pdf*

AAC&U. (2015). What Is a 21st Century Liberal Education? Retrieved from *https://www.aacu.org/leap/what-is-a-liberal-education*

Abelson, R. P. (1995). *Statistics as principled argument.* Hillsdale, N.J.: L. Erlbaum Associates.

American Statistical Association (ASA) Undergraduate Guidelines Workgroup. (2014). Curriculum Guidelines for Undergraduate Programs in Statistical Science. Retrieved from Alexandria, VA: *http://www.amstat.org/asa/files/pdfs/EDU-guidelines2014-11-15.pdf*

ASA. (2014). ASA Guidelines for Undergraduate Programs in Statistical Science: TOPICS. Retrieved from *http://www.amstat.org/asa/files/docs/EDU-GuidelineTopics.docx*

Atwood, R. (2010). It's the breadth that matters. *Times Higher Education*. Retrieved from *https://www.timeshighereducation.com/414650.article*

Cobb, G. (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.

David, H. A. (1998). Statistics in U.S. universities in 1933 and the establishment of the Statistical Laboratory at Iowa State. *Statistical Science*, *13*(1), 66-74. doi:10.1214/ss/1028905974

Ehwa University Department of Statistics. (2018). Statistics blends logical thinking and objective evidence to understand relationships. Retrieved February 20, 2018, from: https://www.ewha.ac.kr/mbs/ewhaen/jsp/organizationCon/organizationView2.jsp?id=ewhaen_030203020000&cateId=78&lan=eng

Engel, J. (2018) *ProCivicStat*. Retrieved March 6, 2018; http://community.dur.ac.uk/procivic.stat/.

Fisher, R. A. and C. S. Stock. (1915). Cuénot on preadaptation: a criticism. *The Eugenics Review*. *7*(1), 46-61.

Gal, I. (2002). Adults' statistical literacy: meanings, components, responsibilities. *International Statistical Review*, *70*(1), 25.

Graber, R. B. (2012). *Valuing Useless Knowledge: an Anthropological Inquiry into the Meaning of Liberal Education* (2nd ed.). Kirksville, Mo.: Truman State University Press.

Hart Research Associates. (2013). It takes more than a major: employer priorities for college learning and student success. *Liberal Education*, *99*(2). Retrieved from *https://www.aacu.org/publications-research/periodicals/it-takes-more-major-employer-priorities-college-learning-and*

McKinsey Global Institute (2011). Big data: The next frontier for innovation, competition, and productivity. Retrieved from *https://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/big-data-the-next-frontier-for-innovation*

Miller, M. A. (2009). Five ways of looking at liberal education. 2009 CCAS Annual Meeting Keynote Address. *http://www.ccas.net/files/CCASNewsletterNovDec2009WEB.pdf*

Miriam, J., & McGlinn, M. (2002). *The Trivium: the liberal arts of logic, grammar, and rhetoric : understanding the nature and function of language*. Philadelphia, PA: Paul Dry Books.

Phi Beta Kappa (PBK). (2017). Starting a chapter. Retrieved from: *https://www.pbk.org/WEB/PBK_Member/GET_INVOLVED/Start_a_Chapter_on_Campus/PBK_Member/Chapter_Management/Starting_A_Chapter.aspx*

Pierson, S. (2014). Bachelor's degrees in statistics surge another 20%. *AMSTAT News* (447), 27-28.

Roche, M. W. (2010). *Why Choose the Liberal Arts?* Notre Dame, Ind.: University of Notre Dame Press.

Salsburg, D. (2001). *The Lady Tasting Tea: How Statistics Revolutionized Science in the Twentieth Century*. New York: W.H. Freeman.

Sandeen, C. (2013). Confronting the Liberal Arts conundrum. Retrieved from *http://www.huffingtonpost.com/cathy-sandeen/confronting-the-liberal-a_b_4107404.html*

Senn, S. (2003). *Dicing with Death: Chance, Risk, and Health*. New York: Cambridge University Press.

University College London. (2017). Department of Statistical Science -- Department History. Retrieved November 9, 2017, from *https://www.ucl.ac.uk/statistics/department/history*

Waechter, S. (2015). The gift of awareness: warn your children about worthless college degrees. Retrieved from *https://www.linkedin.com/pulse/gift-awareness-warn-your-children-worthless-college-degrees-waechter/*

Weisbuch, R. (2016). The liberal arts at war. Retrieved from *https://www.insidehighered.com/views/2016/05/05/values-liberal-arts-and-enlightenment-are-under-attack-essay*

Wikipedia: The free encyclopedia. (2017). FL: Wikimedia Foundation, Inc. Retrieved October 20, 2017, from *https://www.wikipedia.org*. Declaration_of_Helsinki, History_of_eugenics, liberal_arts_education, Nazi_human_experimentation, Tuskegee_syphilis_experiment