Statistics and the Gravity of Education

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In this paper, I build a case for including the study of statistics in a Catholic high school math curriculum.  In the first part, I discuss my previous role teaching statistics in a secular college prep high school; this experience convinced me that the study of statistics is particularly good for older high school students who are about to enter into adulthood because the ideas in the course help to shed light on every day life in a way that allows young adults to enter more fully into “the great conversations” of the modern world. In the next part of the paper, I review my experience teaching statistics in a Catholic school, and I argue that statistics should be included in any Catholic high school curriculum since, among other things, the course opens up the opportunity for “Holy Spirit moments” that link all sorts of contexts to students’ ultimate end: their life in the Kingdom of God.  This leads to the final part of the paper in which I posit that having this supernatural final cause to the teaching of statistics necessarily changes the approach to teaching the course. Although the difference in approaching the course from natural versus supernatural ends is difficult to concretize, I will give some examples of how teaching statistics can create excellent opportunities to “illumine by faith” “the knowledge that students gradually acquire of the world,” (GE 8) a primary goal of any Catholic school as stated in the Second Vatican Council’s Declaration on Christian Education.

  Before building a case for teaching statistics, though, I will confess that I was previously on the other side of this debate.  Upon completing my Master’s degree in mathematics, I looked forward to returning to the career I had started before graduate school as a high school math teacher, and I felt *more* than qualified and eager to teach any high school math course that was thrown my way: all, that is, except statistics.  This, I thought, was not really a math class.  Statistics?! It was too “applied” in nature -- too contextualized and almost artificial. I had cultivated my love for the beauty of *pure* mathematics, and, having recently gone through a conversion from atheism to Catholicism, I saw in my graduate studies *so* *many* proofs of God’s existence and perfection which I couldn’t wait to share with my students.

Nevertheless, I had just gotten married, and my husband had gotten a job at a boarding school teaching English; the school also asked me to teach a couple math classes part-time.

“Great!” I told them. “I’d love to teach anything – except statistics.”

“Oh,” they said, “Well, we need you to teach our AP Statistics course.”

  “What????”

  Now, the only statistics education I’d had up to that point was an undergraduate course on probability and statistics for math majors.  This was a calculus-based course that primarily involved deriving the functions for various probability distributions – as far as I could remember, anyhow.  I did not feel as if I had any statistical instincts or know-how that I could fall back on for teaching high school stats.  Even the couple small units on probability that I had taught as part of the standards-based Algebra 2 curriculum in a public high school (where I worked before grad school) seemed both superfluous and shaky.  At best, I had a rudimentary knowledge of questions such as these: When do we use probability trees?  How can you tell if two events really are independent without knowing their probabilities first?  In short, it wasn’t much for preparing to teach an Advanced Placement course.

So, that summer after I got married, after I finished my graduate school program, in between the waves of nausea that came with my first pregnancy, I dived into the study of statistics from the perspective of an advanced high school / beginning college student.  As I did so, I remember feeling a new excitement about what I was going to get to share with my students.  As previously stated, I had loved teaching calculus prior to graduate school because of the beauty and order that was found so clearly in this powerful branch of mathematics.  But, I had to admit: I had to do some serious ground-work in order for students to appreciate this beauty.  And there were some students for whom the abstraction and the symbolic manipulation of calculus were always just too much of a struggle to appreciate the deeper beauty that was taking shape before them.  But, probability and statistics really were part of their every-day lives.  And helping students understand what was really meant by phrases they heard every day now seemed at least as exciting to me as sharing with them the beauty of calculus.  It was a different kind of excitement, but it was one that would be able to reach even more students, perhaps.

  Though I have always been good *enough* at math, I was never one of those people who could just look at a problem and know immediately how to solve it.  My undergraduate and graduate math courses were very challenging for me, and this is largely why I have always had a heart for weaker math students.  AP Statistics was a class that attracted, in particular, students who were diligent and intelligent, but who didn’t always have the kinds of mathematical minds who would go on to enter into STEM fields.  These were students needing to find a *reason* to study math, since they weren’t headed into fields that would require much.  So, I looked forward to this new teaching challenge – one of helping students develop a new relationship with the study of math, especially if it had not been a good relationship in the first place.  I realized, as I started looking into what the AP Statistics curriculum included, that it was going to give these students an opportunity to see math as useful and even necessary.  And that helped me see it as good, at least for helping them toward “natural” (this-worldly) ends.

  And thus began my first experience of teaching statistics.  It was at a college prep school whose mission was to make sure that students could get into (and be successful at) college.  As a convert, I had never known any different “final cause” to education, so this one really seemed like a good one to me.  The goal of the college prep statistics course was eminently practical; fittingly, it was one that was easily measured and assessed.  Since it was a class for competent students who would likely not be going into math and engineering fields, taking the class was a good way for them to pad their high school transcript with an AP math class in a course that didn’t involve math at its higher levels of abstraction.  Or, if you knew you were going to go into nursing or psychology or other such undergraduate studies that would require statistics, this was a fairly painless way to get it done.  If I were successful, it would mean that, at the end of the year, my students would write “4”s and “5”s on their AP Exams.  They did.  Thus, I was successful.  All was good.

Moreover, for me personally, the course turned out to be very satisfying in that it allowed me to help students interpret the world around them.  In particular, the second year that I taught AP Statistics was a presidential election year.  Statistics and polling results were everywhere. I found myself equipping my students with tools to better understand what they were hearing and better enter the discussions and debates around them.  It was this aspect of the course that really convinced me by the end that I actually loved teaching statistics. But there was yet more to discover . . . and more to love.

  Eventually – after year two -- the demands of motherhood moved me out of the classroom; moreover, our family decided to move to a town with a K-12 Catholic classical mission, one with a heavy emphasis on the final end of education in Jesus Christ.  As I got more and more involved in the school (as a parent volunteer) and saw more and more how different the final cause of a Catholic classical school is from the college prep school where we had previously taught, I recognized more fully what I wanted for my own children (and all of the students at our school) -- fundamentally, I wanted their salvation and sanctification.  If their path to salvation *led* them to college, then certainly I wanted them to be as prepared as they could be for using the gifts God had given them to the fullest, giving glory to Him, and growing in virtue so that they might enter into His Kingdom (and lead others there, too!).  But, it was this *final* end, not just getting into and being successful at college, that was what was in sight at my new school.

  This past year, the school decided to open the door to a new option for math for some seniors: I was asked to teach a statistics class. My first thought was that, though I was eager to teach statistics again, I wondered how it would fit the mission of this school.  It was not only Catholic, but also it was classical.  And I wondered, “how did the modern study of statistics fit into its classical curriculum?”  The school’s math program prided itself on “moments of wonder” – these were days where the classes could pause and appreciate the beauty and order that they found in their studies of various topics that pointed toward God and the infinite. Much like my experience seeing proofs of God in graduate school, this was the way that the school had infused its math curriculum with faith.  The school was finishing its 8th year, 5 of which I had been part of as a parent, none of which included statistics in its curriculum, and things seemed good.  Why hadn’t stats been offered to begin with, and why did it make sense for this school to offer it now?  Upon reflecting on these questions during the summer before I started teaching again, I wrote the following excerpt of my opening letter to my students:

Donahue Catholic is a classical school whose curriculum is formed by classical thought and ideas.  So, one might ask, “why are we including a class on the study of statistics, a modern study, as a capstone math experience for seniors at this school?”  Though the study of statistics is a modern one (the term “statistics” was first used in the mid-18th century to refer to information collected about states and then by the 19th century its meaning was broadened to refer to the study of more general data), it is important to recall that even in the days that Our Lord walked the earth, data were collected about populations.  “In those days a decree went out from Caesar Augustus that the whole world should be enrolled…” (Luke 2:1).

God wrote it into our nature as humans to want to know information about groups of people and to make guesses about information based on the observations we are able to make. We constantly make decisions and choices based on these guesses and the probability of these guesses being correct.  This is Statistics.  So, though the formal study of Statistics, as we know it today is relatively modern in its development, it fits into a Catholic classical curriculum because of its relevance to our daily decision-making and even our human nature.

The realization that one of the most important and essential moments of our faith – the birth of Our Lord – was largely shaped by an act of data collection in ancient times was a huge confirmation to me that, though statistics was a modern field of study, it certainly had practical roots in ancient times and even played a significant role in salvation history.

  This gave me courage to proceed and think about other ways in which statistics fit the mission of our school, which is certainly in keeping with the principles laid out by *Gravissimum educationis*.  So, let me return to that paragraph that I referenced from this document at the beginning of my talk.  The Second Vatican Council says of a Catholic school:

… its proper function is to create for the school community a special atmosphere animated by the Gospel spirit of freedom and charity… to order the whole of human culture to the news of salvation so that the knowledge the students gradually acquire of the world, life and man is illumined by faith (GE, 8).

This is a tall order, and, for those of us teaching in Catholic schools, the job is not an easy one.  However, once I was at peace with the justification for why the class should be offered at our school, I found myself frequently thinking of reasons why the material I was covering in statistics was so important for our students in light of our mission.  And, because of this, suddenly I found my teaching changing in fairly dramatic ways – all because the final cause of the setting had changed dramatically.  In one setting, the final cause for one of my students was success in college.  In the other, the final cause for one of my students was deepening their knowledge of and relationship with God as well as deepening their knowledge of truth and developing an integral understanding of truth.

  To be sure, in many fundamental ways, the difference in my teaching approach with these different final causes in mind has been negligent.  The informational material used, the intellectual challenge of building a statistical toolbox of analytic tools in order to perform methods of statistical inference, and the ways in which a high school student’s brain must be primed and fed in order to internalize this material and develop skill at using these methods are all the same in both settings.  However, in some less concrete ways, my teaching approaches have been worlds apart.

  In preparing for this paper, it was tempting for me to try to compare the differences of teaching in these two settings as if I were approaching a problem in statistics.  I wanted to quantify the two experiences, somehow, and analyze them, determining through statistical inference whether there *is* a significant difference in the teaching methods that come from the difference in ends or final causes of these two settings.  However, my own experience – confirmed by a recent scholarly article on the topic – has convinced me otherwise.

Robert Winthrow’s recent article in *First Things* entitled, “In Polls We Trust,” reflects on the problems inherent in statistically evaluating key religious topics. Bringing this article into the classroom for discussion, I and my students that read and discussed Winthrow’s compelling claims. He argues that “as it presently exists . . . polling about religion is troubling not because it is always wrong, but because it has become difficult for anyone to know when the results are correct and when they are not.”[[1]](#footnote-1)  Moreover, “polling has taught us to think about religion in certain ways that happen to be convenient for conducting polls.  The questions tap a few aspects of belief and behavior that can be tracked as trends and rarely provide opportunities to hear what people actually think.”[[2]](#footnote-2) Related to this conclusion that *he* came to, the conclusion that I finally came to was that no amount of polling or data collection or statistical analysis can demonstrate the significant difference in the approaches to teaching that stem from the difference in final causes of the two settings in which I have taught statistics because one of the final causes lives *in the supernatural realm*.

  This is really important.  And though it doesn’t affect every aspect of my daily lesson plan, it informs my every teaching moment.  I am thinking about everything I teach in terms of my students’ life in Christ.  This means always being open to the Holy Spirit who might guide me in a new way in the middle of covering this or that topic in class because suddenly I’m made aware of repercussions of that topic which I hadn’t even considered.

  I had one of these moments in the middle of going through a problem about conditional probability with my class.  One of the great things about the material we cover (and the particular textbook that we use!) is that almost all of the problems we do all year long come from actual, cited, real-life data.  Students are gaining knowledge about all sorts of worldly areas, and getting to analyze data that has actually been collected about these areas, in every single homework assignment.  In this particular problem, we looked at statistics involving medical testing.  The problem read:

Enzyme immunoassay (EIA) tests are used to screen blood specimens for the presence of antibodies to HIV, the virus that causes AIDS.  Antibodies indicate the presence of the virus.  The test is quite accurate but is not always correct.  And then the problem gave the approximate probabilities of positive and negative EIA outcomes when the blood tested does and does not actually contain antibodies to HIV

|  |  |  |
| --- | --- | --- |
| Truth | + Test result | – Test result |
| Antibodies present | .9985 | .0015 |
| Antibodies absent | .006 | .994 |

The problem asks the student to suppose that 1% of a large population carries antibodies to HIV in their blood and that we choose a person from this population at random.  The problem says, “If you know that the EIA test from that person is positive, find the probability that the person has the antibody.”  The answer is rather surprising.  Let A = having the antibody and let B = having a positive test result.  Using the conditional probability formula of P(A|B) = P(AB)/P(B), we can find the probability of having the antibody (A) given that the test was positive (B).  We know that P(AB) = P(A)P(B|A) = .01(.9985)

Also, it’s easy to show through Venn diagrams that

P(B) = P(A)P(B|A) + P(Ac)P(B|AC) = .01(.9985) + (.99)(.006).

So, P(A|B) = P(AB)/P(B) = .01(.9985) / [.01(.9985) + (.99)(.006)] = .6270

What does this mean??  It means that there’s a 62.7% chance that the person chosen from the population *actually* has the antibody even though we started by knowing that his/her test for it was positive!  Thus, when we got to the end of the problem, we realized how likely it was that, if someone has had a positive test result (even from a test that is very accurate), then they still might not actually have the HIV antibody (almost 38% chance!).  “This is so important!” I exclaimed. “Do you know how often pregnant women are encouraged to have prenatal testing done with the same kind of false positive rates (actually the initial tests done often have much worse false positive rates)?  Do you know what happens when women get positive results from a prenatal test?”  I know how real this is because I happen to have a very close friend who had such a positive test result and her doctor already started talking about her “options” if further testing confirmed the initial result.

  When I had taught this same problem in the secular college prep setting, my concern was simply that the students understand how surprising conditional probability results can be.  That was no longer the case when teaching students for whom I had a supernatural end in mind.  Discussion about conditional probability segued easily into a discussion about responsible use of pre-natal testing and the dignity of all human life as well as the importance of being aware of and perhaps even involved in such issues.  My students were clearly able to see how great a problem pre-natal testing can be when used without a) an understanding of the probabilities involved and b) a belief in the dignity of all human life.

  This is really the HUGE difference in the two settings in which I have taught statistics.  One is illumined by faith (and therefore, in it we see the connections between statistical methods and practice and what the truths that are found there then imply about real-world contexts), and one is not.

  Another example we’ve seen is one that explored the correlation between quantitative variables.  The problem illustrated the strong positive relationship between a higher rating of social distress (from being socially excluded or rejected) and a greater level of brain activity in the region of the brain that is activated by physical pain.  It was clear from this problem that social trauma from exclusion registers as physical pain in the person being rejected.  It’s obvious that this is the perfect moment to reinforce the importance of charity in our life in Christ.

Even the practice of writing the full explanation of a problem involving statistical inference becomes a moment to talk to students about how important it is, as we take up the call of the New Evangelization, to become experts at laying out arguments.  Writing out a clear statement of our question, a plan for how we mean to answer it, an explanation of our method, and finally a conclusion answering our original question unambiguously gives us excellent practice in the art of apologetics.

  These are just a few examples of the countless opportunities that I have found in teaching statistics at a Catholic school to link content about various topics to my students’ lives in Christ and their striving toward the Kingdom of God.

 Let us listen to the Declaration on Christian Education one more time in conclusion:

So indeed the Catholic school, while it is open, as it must be, to the situation of the contemporary world, leads its students to promote efficaciously the good of the earthly city and also prepares them for service in the spread of the Kingdom of God, so that by leading an exemplary apostolic life they become, as it were, a saving leaven in the human community (GE 8).

  In conclusion, the teaching of statistics truly lends itself to opening up opportunities for the teacher to allow the Spirit to guide lesson preparation and implementation. It is best, then, to allow this course into the Catholic schools so that students can better be equipped for the New Evangelization. Moreover, my experience teaching the course in both Catholic and non-Catholic settings confirms for me that fixing the course with its proper end in Christ opens it up to new and better paths that best illumine for the students how statistics fits into God’s all-loving plan.

1. Robert Winthrop, “In Polls We Trust.”  *First Things*, August/September, 2015.   p. 44 [↑](#footnote-ref-1)
2. Ibid.   p. 42 [↑](#footnote-ref-2)