USE OF TECHNOLOGY IN CREATING PROJECTS FOR NON-STEM FEILDS

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Abstract
In this paper we will discuss our work in introducing non-STEM students to techniques of modeling and quantitative applications through projects related to their area of study. A common feature of these projects is the use of real data and commonly available technology, such as CAS and statistical software. In these projects we have attempted to model current or historical events relevant to specific non-STEM disciplines. In the projects we pose questions and hypothesis that challenge students to separate myths from facts using quantitative analysis. We will include a sample of our projects to demonstrate the breadth of applications. We will then discuss the benefits to students, including literature search skills, use of technology and becoming familiar with significant current and historical events of significance. These projects are created by the authors and teams of faculty and students from non-STEM disciplines for use in their major or general education courses. The projects are suitable for use in disciplines such as social sciences, theology, kinesiology, history, literature, and psychology. We will conclude by discussing the instruments used to measure the expected change in attitudes of students toward quantitative analysis after the use of these projects. Several of our examples were created as part of the NSF funded grant titled "Math-Stat Modeling Across the Curriculum."

Keywords: Statistical modelling, modules, non-STEM

Introduction
The authors have been using technology in the mathematics and statistics classes at Texas Lutheran University for close to three decades and are true believers in the power of Technology, CAS, and online resources as investigative tools to help develop students understanding and appreciation of mathematics and statistics. The work in which we are currently involved gives us an opportunity to reach out across disciplinary boundaries and introduce non-STEM students, who in some cases are unaware of or fearful of quantitative methods, to the power of quantitative reasoning which can be beneficial in almost every field of study. We will begin our paper with a rationale for our project . We will then present the methodology used for our study which includes brief description of the NSF grant that has been a major contributor to the success of our project . After

introducing a sample of projects, we will discuss challenges in measuring attitudinal changes.

Rationale for our Project

There have been many studies, books, and articles concerning innumeracy in America. John Allen Paulos in his best-selling book describes Innumeracy as the mathematical equivalent of illiteracy—incompetence with numbers rather than words. Often, students and others (particularly individuals with non-STEM majors or jobs) will admit, as a badge of honor, that "Math was never my thing." What a shame that is. Innumeracy cuts one off from quantitative analysis of problems in business, political science, sociology, history, art, etc. Innumeracy makes math and statistics foreign languages that you don't speak. Increasingly decisions of importance to us all are being made through collection and quantitative analysis of data. An educated person cannot afford to be divorced from these activities. To confront Innumeracy, students need to be made aware of the importance of quantitative applications in their field. They need to learn to appreciate the power of quantitative applications and to learn that performing quantitative work can be part of their skill set. Why would there be resistance to quantitative reasoning? We think there are many possible answers to that question: bad elementary school experiences, false dichotomy of abilities (STEM vs Humanities: you are one or the other). Whatever the reason, we think it is worth the effort to increase the appreciation of quantitative reasoning in all university students. At university math and statistics departments teach quantitative skills. However, studies have shown that techniques learned in the math/statistics classroom may not transfer to other classrooms. That is unfortunate but suggest to us that there is an important role for quantitative methods being used consistently in the non-STEM classroom. To better reach all students we are eager to encourage our peer faculty members in non-STEM disciplines to include quantitative topics more readily in their courses.

To these ends we created "Mathematical and Statistical Modeling Across the Disciplines." Among the aims of this initiative are:

Create a framework in which non-STEM students will be exposed to some aspect of quantitative reasoning in a course or courses in their home discipline,

Encourage non-STEM faculty to include quantitative methods in their courses at points that they think are appropriate,

Create an archive of "turn-key" applications that non-STEM faculty can incorporate into their class with a minimum of effort and planning on their part.

Our Methodology

We sent out a call to non-STEM faculty to join us in imagining and creating short quantitative modules that would be relevant to practitioners of non-STEM disciplines. Because of NSF funding (NSF Grant # 1905246 *Mathematical and Statistical Projects Across the Curriculum : Empowering Non-STEM Students to Appreciate and Use Quantitative Modeling-M^2AC*) we were able to offer substantial stipends to faculty who worked with us. In addition to faculty from non-STEM disciplines we recruited and rewarded several faculty, skilled in quantitative matters, to serve as mentors to non-STEM faculty as they created their own quantitative models. Expressed in more direct terms, we recruited non-STEM faculty for their knowledge of where, in their own

discipline, one could find good quantitative applications. Through stipend awards we made it possible for these faculty to spend the requisite time and energy to develop modules that would be useful in their own classroom and interesting to others in related disciplines. To facilitate the development of a module we assigned an experienced mentor to each participating faculty member. In this way we have created numerous modules that have been tested and are available for use in the classes of any faculty member who wishes to participate.

As we mentor the creation of modules a consistent goal has been to teach students how to research a topic, whether the topic involves current or historical events. In this context we use research to mean a directed literature search and the gathering of appropriate data. Then they will use their "research" to transforms data into knowledge. Also included in this training would be the use of the technology that makes many formerly laborious quantitative tasks now within the reach of undergraduate students with minimal hardware requirements.

So that the reader can appreciate the diversity of modules that we have been able to nudge into being, we will go over several examples. As you read these examples remember that the purpose is not original research. Rather the goal is to expose non-STEM students (and perhaps their faculty) to the power of quantitative investigations in a variety of current and historical events.

A module for kinesiology /sociology: The Home Field Advantage

There is always talk of "home field advantage." One can imagine that familiar environs convey an advantage, perhaps better rest because of the relaxed demand for travel, maybe some fluke of the field or pitch may lend itself to a home team win. Or perhaps it is the fans, cheering on each positive play and expressing disappointment for each "less than expected" move. The latter has been difficult to test because the fans were ever present, that is until Covid-19 required teams to play to empty stadiums. Comparing data from the British Premier League Soccer Matches over a twenty-year period, calculating the ratio of home wins to away wins, one finds that during the year without fans the ratio of home wins to away wins dropped to a twenty year low of 1.17. That suggests that the likelihood of an at home win and an on the road win are nearly identical. This project does ask students to gather some data in order to investigate a question but does not require much math and statistics beyond calculating ratios and averages. There conclusions can be dramatized by the inclusion of bar charts or histograms which are easy to create using ubiquitous statistical software.

A module for history: World War Two: How many tanks were the Germans producing?

For obvious reasons it was of interest to the allied forces to know how many tanks German industry was able to produce. Equally obviously, was that production was a closely guarded secret. However, using serial numbers from transmissions of captured and/or destroyed German tanks and a clever bit of statistics the British were able to closely estimate the production. The technique, which can be applied to many other historical and current estimates, is to let the number of captured tanks be represented by

the letter K, and the maximum serial number we have seen be represented by the letter M, then we can estimate the maximum number of tanks with the equation:

$$\text{Max production} \approx \boldsymbol{M + \frac{M}{K} - 1}$$

which can be shown to be the uniformly minimum unbiased estimator of the max production. But of course, in a, say, history class, one can explain the method and the useful results obtained without excessive use of higher-level statistical concepts.

A module for biology and epidemiology: Who is susceptible to a covid infection?
This module was especially timely for introductory biology or epidemiology classes because of all the news concerning the Covid Pandemic. A first learning experience was how to critique data. Much data was readily available, but it was of a range of reliability. After data was captured it could be probed in multiple ways to see if it would reveal at risk subsets of the population or perhaps geographic areas that were being especially hard hit. Students using this module captured data and using statistical software did a multiple variable linear regression to predict total covid cases. The most useful predictors were found to be: Population Density (continuous), Gross National Income (continuous), Average Age (continuous), Shelter in place order (binary), Democratic or Authoritarian government (binary), and Island or Mainland territory (binary). The conclusion reached was that to protect yourself from covid-19, it is best to be young, live in a less-than-prosperous and sparsely populated island country, governed by a non-democratic system!

A module for theology/religion/sociology
This module was created by a theology professor who posed the question "What does God look like to Gen Z?" Traditional views of God include: benevolent, distant, critical, authoritative,…. But do these views persist in Generation Z students?
To investigate this question students created survey instruments, administered surveys, and analyzed the results. The surveys not only investigated the Gen Z God Image, but additionally gather data on how their view of God informs their actions. Results were translated into tables and graphics to explain what the data tells us. This group of students, under the skillful guidance of a talented and dedicated professor, learned not only theology concepts but also learned something about the usefulness of quantitative investigation and learned that quantitative investigation was something that they could do.

A module for literature/ history: Who Wrote That?
In 1861 a series of humorous letters from Quintus Curtius Snodgrass were published in the New Orleans Daily Crescent. These letters chronicled the participation of the author in a local southern militia. In the years since 1861 there has been speculation that Quintus Curtius Snodgrass was a nom de plume of Samual Clemens (Mark Twain). And why would this matter? In later years Samual Clemens became a close friend and advisor of Ulysses S. Grant. From a Confederate sympathizer and participant to a prominent backer of the most important Union general and former U.S. President would be quite a journey. Is Samual Clemens really Quintus Curtius Snodgrass?
To investigate the question, we used "Stylometry." Stylometry is a procedure that uses two or more lengthy samples of, in this case, the Snodgrass letters and from uncontested

Clemens writing. Using technology (R and a stylometry package) we removed numbers, punctuation, "stop words" such as and, or , etc. from both samples. Next we count word frequency in each sample and perform "cluster analysis" (or other) measures of similarity on the samples. Did Mark Twain write the Quintus Curtius Snodgrass letters? Most likely **Mark Twain is not the author** of these letters.

Evaluation: Data gathering and surveys

Faculty who used a module agreed to administer short pre and post surveys to their students. The survey was designed to measure the following factors:

- Mathematical/Statistical Disposition [e.g., "I truly enjoy math and/or statistics"]
- Comfortableness Using Math/Statistics [e.g., "I can use Excel or other math software to run basic statistics"]
- Applications of Math/Statistics [e.g., "I understand the importance of math/statistical procedures to test the validity of a claim"]
- Value of Quantified Data [e.g., "I believe that to truly understand something, it is best to create and examine numerical data"]

Analysis of the survey data disclosed modest gains, but any gain was seen as a success. Negative attitudes toward quantitative work had been built upon for twenty or more years. It is hardly credible to believe that a onetime positive exposure to quantitative methods would result in more than a modest turn around in attitude. Still, a small gain is a step in the correct direction. Various other bits of data came from the survey, for example that men made larger gains than women.

After examining the first round of survey data we asked ourselves if the lack of immediacy effected our results. The surveys were given at the beginning of the term and at the end of the term, which may be several weeks after the student was immersed in the quantitative module. In an effort to get immediate feedback from students we created three "reflection questions" that were asked immediately upon completion of the module. The questions were:

1. Tell us something that influenced your attitudes toward Math/Statistics in a positive way.
2. Tell us something (at least one thing) that you found challenging.
3. Anything else (at least one thing) you want to share about the experience?

The reflections provided by students revealed that they were getting a lot out of the modules and that there was generally a deep appreciation for their inclusion in the class they were taking.

The Archive

A third goal of this program, briefly mentioned above, is the creation of an archive in which we will store student versions and faculty versions of the modules created. The archive is accessible to everyone and stores "turnkey ready" quantitative applications that a faculty member can incorporate into his or her class with a minimum of extra preparation on their part. We understand that faculty are busy people and do not always have the time or resources that they need to do everything that they would like to do. If a faculty member goes to our archive and finds a topic that fits the course they are teaching

they will also find directions and background information on the topic written for a busy faculty member. Hints on teaching the module will be included as well as directions for students along with any needed worksheets or background readings. We are striving to make the modules available with a minimum of time investment on the part of the user. You can find the archive at **https://www.tlumathcsis.org.**

Conclusion

We firmly believe this project sets the stage for impacting and sustaining positive attitudes toward the inclusion of math and statistics across disciplines, by students and faculty alike.

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