Engaging Crisis: Immersive, Interdisciplinary Learning in Mathematics and Rhetoric

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Abstract

This paper describes an interdisciplinary activity that crosses over between Mathematics and Rhetoric. The professors who created this activity both sought active-learning opportunities for their students, a sense of realism—even urgency—in what can otherwise be perceived as abstract material, and a meaningful liberal arts experience. Evidence of the power of this experience is seen in the media coverage, both from our college and from the *Portland Press Herald* newspaper. Both courses described in this paper are at the elective level, taken by majors or minors in their respective disciplines. Students have moderate to extensive backgrounds in their subject areas. However, adapted versions of our activity could involve students at more introductory levels.

1. Background

Recent years have seen an increasing attention to, and call for, "engaged learning," "interdisciplinarity," "transdisciplinarity," "public intellectualism," and "experiential learning" among others as ways to promote and teach critical thinking. Unifying these goals is a belief that agents of change—which we want our students to be—are more efficient and effective when creating knowledge from multiple wells of information, and that these styles of education equip citizens for participation in the public sphere.

Concurrent with academic attention to increasing the base of shared knowledge has been the reduction and oversimplification of argument in the public sphere. "Truthiness," "post-factual," "fake news" and other buzzwords speak to the relative and contingent nature of knowledge that is considered valuable. Meanwhile, the STEM disciplines have in recent years been deemed worthy of increased funding and educational focus, yet frequently they are presented in the public sphere and popular culture as subjects to be feared or distrusted. These cultural observations are highly contemporary, yet also reflect the distinction made as far back as Aristotle between modes of persuasion involving *logos* and those involving *pathos*. Post-Enlightenment thinking that privileged the "rational" or "scientific" over the "emotional" or "humanistic" over-simplified and bifurcated ways of knowing not meant to be separated. Therefore interdisciplinary, engaged learning reconnects and highlights the interdependent nature of knowledge.

Teaching students how to ethically and effectively combine the multiple modes of persuasion, and to look to multiple disciplines for the inventions of arguments, were the primary goals for Rhetoric students in the exercise described below. Teaching students how to use mathematics in an immediate and realistic environment, requiring both math content and communication skills, were the main goals for Mathematics students in the exercise. As noted by Depew and Lyne [10], rhetoric extends the tentacles of conceptual grasp and thus can be deployed by science to promote a more informed public sphere.

In this paper we describe an activity (a sudden-outbreak mock crisis) that allowed us to bring together two elective courses, one from Rhetoric (Presidential Campaign Rhetoric) and one from Mathematics (Mathematical Epidemiology), and to enrich the student experience in both. In discussing our courses, we note several past collaborations between mathematicians and humanists, as readers considering new partnerships may wish to scan multiple ideas [3, 8, 16, 19]. Evidence of the power of our experience is seen in the media coverage, both from our college [6, 9] and from the *Portland Press Herald* newspaper [12].

While working together, we have found tremendous overlap in our learning goals for students and our disciplines' best practices for pedagogy. Because our aims were essentially the same, we were able to explore the complementary trajectories of our learning goals. Both of us sought to have students realize the instrumental nature of our respective topics in the real world while also teaching them how to operationalize theories from our disciplines.

Toward those ends, we had each already tried various traditional, intradisciplinary class approaches. This collaboration, therefore, allowed us to add a sense of urgency and depth to what had been two distinct activities. The collaboration further prompted students to consider how the exercise topic embraced both mathematical and rhetorical sites of knowledge and production of meaning.

We begin by describing each course and the ways the shared activity served the learning objectives of each course. Next, we provide concrete description and explanation of the activity, noting the consequences of the different scenarios chosen. Finally, we conclude with a discussion of the outcomes — both intended and unintended — and circle back to the larger issues of knowledge creation and dissemination in which this activity and collaboration are grounded.

2. Presidential Campaign Rhetoric Overview

Presidential Campaign Rhetoric is a common staple of most communication studies departments, and oftentimes is taken as part of a focus on political rhetoric in conjunction with other traditional public address courses. Those of us teaching at small liberal arts schools, however, are unable to offer several courses on traditional public address, political rhetoric, or campaigns. In order to cover several topics we often combine these, necessarily sacrificing depth for exposure.

In the late 1990s, Kelley-Romano developed Presidential Campaign Rhetoric to expose students to traditional approaches to public address as well as historically significant texts. At first, the course covered only the history of presidential campaign rhetoric. This approach presented three main problems. First, the historical approach was not particularly engaging to students, and they were oftentimes very unaware of, and uninterested in, the broader socio-political context in which campaigns happened. Second, since examples used in class were often the most successful or noteworthy texts, students were only seeing the trajectory of historically successful rhetoric. As such, it was hard for them to understand the complexities of the rhetorical choices faced by campaign staffers and candidates. Finally, while rhetoric students were well versed in the creation and performance of persuasion, they often lacked substance or nuance around relevant issues. This resulted in complicated topics (e.g. climate change) being reduced to primarily emotional appeals based in fear or obligation. To address these issues, a mock campaign was added to the course.

The current iteration of Presidential Campaign Rhetoric resembles little the traditional public address class that was its beginning. Instead, the course is now an immersive, interdisciplinary campaign experience. Typically, there are two campaigns. Each campaign includes candidates, running mates, press secretaries, campaign managers, speech writers, and media directors. Campaign teams plan, design, and run a presidential campaign that lasts ten weeks. In this time, campaigns create a platform, plan announcement events, host conventions, conduct voter outreach, participate in two debates, run ads, do fundraising, and deal with scandals and crises. Meanwhile, several students from the course serve as the media: maintaining blogs, setting the agenda, and publishing bi-weekly newspapers.

Following a course redesign supported by Bates College in 2014, collaborations by multiple programs and disciplines were central to learning outcomes. Topically relevant courses were enlisted to creatively engage with the campaigns and provide them more substantial information. So, for example, an International Politics class consulted with the 2014 campaigns about drone strikes, and then later, the class became the media for a press conference where the campaigns fielded questions about the information on which they had been briefed. In both 2014 and 2016, Sociology students conducted polling about issues relevant to the voters, and did polling following the debates which helped direct the campaign. A Music class consulted with the 2016 campaigns about appropriate music for their conventions. In both years, other classes wrote editorials discussing issues of race, sexuality, or gender that were operational in a particular campaign.

3. Mathematical Epidemiology Overview

Students in this math modeling course learn how to build compartmental models of disease spread, sometimes referred to as SIR-style models, using systems of ordinary differential equations. They read news articles and book excerpts about diseases, and they study and present professional journal articles about disease models. They mathematically analyze models using techniques drawn from courses such as calculus, linear algebra, and differential equations. They collect data sets for specific outbreaks and estimate best parameter values for fitting their models to data. Assessment of student work relies primarily on homework, engagement in course activities, and papers, rather than focusing on quizzes or exams.

This course dates back to the 1990s under the title Mathematical Models in Biology, and it has always been one of the most applied courses in the mathematics department. Prior to 2014, the course covered more topics, each in a more cursory way. These included ecology and molecular evolution, along with infectious disease. Student evaluations from earlier offerings show great appreciation for seeing how mathematics can be used outside the classroom.

Yet curriculum recommendations, such as those from the Mathematical Association for America [15], recommended we do more. The MAA states that mathematics courses for majors "should present key ideas and concepts from a variety of perspectives to demonstrate the breadth of mathematics" and says that mathematics students "should experience mathematics from the perspective of another discipline." Especially relevant, the MAA writes in favor of "a mathematical modeling course that asks students to deal with complex real situations and that is project-based with a heavy emphasis on communication skills." Work with data is also valued.

The resulting transition to a full-semester course on Mathematical Epidemiology occurred concurrently with Bates offering new courses on different types of mathematical modeling. This made it feasible to bring new depth to the course: rather than touch on several modeling ideas, students learn more details about a particular set of modeling approaches, delving into theory and applying their knowledge to multiple projects in a scaffolded manner. They begin with basic models, artificially simple data sets, and highly structured assignments, then build up to complex models, realistic and messy data sets, and a great deal of freedom in determining projects. Along the way, they interrogate how mathematics and data are used in current-day public health policies — college campuses often provide first-hand examples of outbreaks in a defined set of individuals (students!) — and, with the Presidential Campaign Rhetoric course, they find themselves suddenly called upon to provide expert and immediate consultation regarding a new outbreak.

The sudden outbreak exercise that we developed puts mathematics students into an unexpected situation needing quantitative and modeling expertise. There are several objectives once the mathematics students are in this situation. First, they should recognize that their mathematical knowledge contributes to the goals and outcomes of the Presidential Campaign Rhetoric students in their roles as campaign staff or media. Second, they should identify — and use — several specific mathematical approaches for analyzing the crisis. Third, mathematics students should build understanding of the ways mathematics is valued and discussed in the public sphere.

Last and definitely not least, they should emerge with a sense of the immediacy and the crucial nature of mathematical knowledge, and that sense should motivate them in their continued studies of even the most abstract mathematical concepts.

4. Shared Activity: Mock Crisis

In virtually every U.S. Presidential election there are dramas, crises, and disasters to which candidates need to respond. While some are manufactured, or conveniently released by the opposition, sometimes these exigences are broader in scope and require more nuanced responses. Meanwhile, in each of these two courses, our goal is to have students engage with theoretical material in real world situations and conditions in "real" time. As noted by Harris, Walsh, and Miller, there is a difference between studying persuasion and making persuasion happen [7]. Nilson [18] describes experiential learning, including simulations and role-playing, as "ensur[ing] higher student motivation, more learning at higher cognitive levels, greater appreciation of the subject matter and its utility, and longer retention of the material than does the traditional lecture."

This activity is therefore designed to put students from both courses in the middle of a crisis: students hear that some sort of disease has reached a critical point nationally, thus generating the need for a response by candidates that incorporates data-driven expert knowledge. Presidential Campaign Rhetoric students are forced to contemplate the many choices faced by a candidate and a campaign. Do they postpone a debate? Do they visit the site? Do they offer suggestions to lawmakers or the American people? Are they strong leaders? Does their statement lead the news cycle? Mathematical Epidemiology students must respond quickly, providing disease knowledge and model-based estimates of possible outcomes, relying on the data, models, theory, and simulations they have learned during the semester. They work only with their mathematical understanding so far, supported by their class notes, their computer simulations of epidemiological models, and whatever new disease-related information they can find online during the timeline of the crisis.

We have run this scenario twice: once in 2014 when the crisis was an Ebola outbreak and once in 2016 when smallpox was the center of the crisis. The crisis unfolds over two days. Students in Presidential Campaign Rhetoric attend class on Day One as if it were any other day, unaware of what is about to happen. Kelley-Romano introduces herself to them as an official from the Centers for Disease Control and Prevention (CDC) and reads a press release involving concerning, yet purposefully vague, information about the disease outbreak.

On Day One of the crisis, campaigns are required to post a statement on their campaign webpage within 90 minutes after the initial briefing from Kelley-Romano. Then, students monitor social/mock campaign media for breaking news being released by other members of the course who are in the media pool.

After posting their initial statement, Presidential Campaign Rhetoric students are informed that more information will be made available the following day from the CDC and that a second, "televised" (video) statement is due on Day Two. Candidates are also told they will be required to field questions from the media, and from CDC officials, following their televised statement.

To prepare for their video statements, Presidential Campaign Rhetoric students visit the Mathematical Epidemiology classroom (Figure 1). Students in Mathematical Epidemiology do not know about this activity in advance, but they are advised to bring notes and laptops to class. During their visit, Presidential Campaign Rhetoric students request expert consultation for their upcoming video statements from the Mathematical Epidemiology "CDC consultants." These "consultants" are split into three groups, which advise the Democrats, the Republicans, and the media. Consultations last approximately one hour.

Figure 1: "CDC Consultants" (Mathematical Epidemiology students) work with the Media group from Presidential Campaign Rhetoric. Photo by Phyllis Graber Jensen.

As consultants and campaigns discuss the crisis, many factors are raised (often hysterically by campaign staff) and can be accounted for, and explained, by Mathematical Epidemiology students. For example, what are projected death tolls, and should there be an immediate travel ban to limit disease spread? Should quarantines be established in the initial locations of the outbreak? Mathematical Epidemiology students discuss disease details in their roles as CDC officials, using their backgrounds in disease study, data collection, and modeling to inform candidate responses. Campaigns' final statements then offer suggestions as to the relevant factors and potential policies at play—with Presidential Campaign Rhetoric students keeping in mind they are candidates in the middle of their campaigns. Mathematical Epidemiology students are then invited to subsequent press events for Presidential Campaign Rhetoric, and some "CDC consultants" reprise their roles to pose scientific questions of the campaigns at those events (Figure 2).

Figure 2: Recording the final video statement for the Democratic candidate: students from both courses pose questions. Photo by Phyllis Graber Jensen.

In order for students to have the necessary tools to participate in the crisis activity, we each provide theories, technical knowledge, and general information beforehand. We find that each of us can integrate the necessary content easily

within traditional course units. At the same time, we work to maintain the surprise, and therefore do not tell students that there will be a crisis, or how the specific information they are learning will help them during the crisis.

Providing students with the necessary theoretical background for responding to crisis from a rhetorical perspective is fairly straightforward. A literature exists on response rhetoric and contemporary examples are abundant. Readings and discussion questions prompt students to think about the necessary difference in response between natural vs. human-caused crises.

Compartmental models, including the SIR model shown in Figure 3 and described via system of equations (1):

$$\frac{dS}{dt} = -\beta SI$$
$$\frac{dI}{dt} = \beta SI - \gamma I \tag{1}$$
$$\frac{dR}{dt} = \gamma I$$

are at the core of the Mathematical Epidemiology course. The three compartments of the SIR model represent three distinct states during an outbreak; at any given time, each person in the modeled population resides in exactly one compartment. The S compartment is for Susceptible individuals, who have not yet become sick, but could. The I compartment includes currently Infectious individuals, meaning both that they are sick and that they can spread disease. The R compartment is for Removed individuals, meaning that they have already been sick and are no longer able to become sick or to spread disease. The term βSI indicates interaction between Susceptible and Infectious individuals, with the parameter β determining how likely it is for an interaction to lead to a new infection. (Notice that when there are very few Susceptible or very few Infectious people, there is little chance for interaction and βSI is relatively small. When both the S and I populations are relatively large, there can be more interaction, and the value of βSI is larger.) The γI term governs movement of individuals from the Infectious to the Removed compartment.
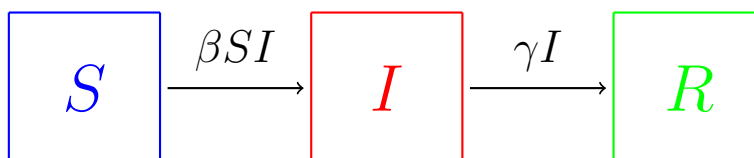

Figure 3: Sample SIR (Susceptible-Infectious-Removed) diagram.

This SIR model is just one possible compartmental model for describing disease spread. Different or additional compartments are possible, for instance for people who have contracted a virus but are still in the incubation period before becoming infectious, or for individuals who are isolated after they are known to be sick. It is also the case that the formulas on the arrows can be different from those shown in Figure 3 and appearing within equations (1). Examples include alternate interaction terms as well as permitting formulas to change as a function of time, such as by decreasing β during an outbreak to correspond to lower infectivity due to public health interventions. For an introductory paper showing additional models and their connections to real-life data, see [13]. Textbook descriptions of compartmental modeling and related mathematical analysis include Chapter 6, Section 6, of [11], Chapter 3 of [5], and Chapter 9 of [4].

Before crisis day, mathematics students are well-versed in SIR models as well as variations showing demographic change, vaccination, isolation, quarantine, public health interventions, and more. Students have also read extensively in advance about the crisis disease (such as Ebola or smallpox) and have gathered data and written papers on the crisis disease, so they know clinical details, have models already built, and have estimated reasonable parameters for those models.

Students provide immediate feedback on the crisis event less than a week afterward, then comment at the end of the semester on the role of the crisis in the trajectory of the overall course. These are chances for them to mentally process the event in two different ways. Their writing also serves as an assessment of the activity for both professors to use while planning future crises.

5. Discussion and Conclusions

In addition to the pedagogical implications of the crisis activity for students, this collaboration between mathematics and rhetoric affirms the necessity of "transdisciplinary research" necessary for public intellectualism and change [7]. We have discovered tremendous similarity in our goals regarding the process of acquiring knowledge, yet only after many conversations and much translation of jargon between disciplines. Our enhanced understanding of the connections between our work prompts each of us to posit debriefing questions to our classes that encourage interdisciplinary thinking.

The important takeaway is that students achieve all the goals and objectives described in Section 4. In particular, they write extensively about the surprise of the visit between courses and the excitement of working in conditions where mathematical knowledge is so immediately needed and highly regarded.

As with any experiential learning activity, often the things learned which are unanticipated are the most interesting. Students muse about the ways the campaigns work to spin the mathematical analysis to best support goals of the presidential candidates, describing detailed back-and-forth conversations needed for this process. As one says, "I have never taken a course at Bates where two seemingly incomparable courses come together and work to produce a final product." Several students describe the limited amount of time each college student has to take courses, saying they value the opportunity to connect with a course they are not likely to take: this broadens their understanding of the types of courses, and the ways of thinking, experienced by other students. Mathematics students comment on needing to find ways to explain their mathematical knowledge to campaign and media staff who have not studied the same concepts, while campaign/media staff must quickly learn new technical information from live "experts" as part of responding to an urgent crisis. As described in one feedback essay, "Even if the results that a scholar found are quite substantial, being able to effectively communicate that to people in other areas of study is, as I learned from the presidential campaign class visit, quite difficult."

This activity exposes students to the role of the "expert" in the public sphere and the way scientific knowledge is incorporated into mainstream political discourse. In a world where truth has become relative, and increasingly partisan, it is essential that student-citizens learn to evaluate truth claims and use mathematics and science when necessary and relevant. Part of our hope when constructing this activity was to convince students that an informed perspective is better than a simply emotionally persuasive one.

For future iterations of this activity, Kelley-Romano's rhetoric students will be asked to explicitly address the difficulty of incorporating scientific language, theories, and expertise into the often oversimplified world of political campaigns. Greer has updated preparation to be sure that her mathematics students bring all relevant sets of notes and computer programs to class, even though they do not know what will be happening.

Both professors have learned to insist that students emphasize, in all communications (especially social media posts), that the outbreak is NOT REAL.[1]

A version of this activity could occur in a less-specialized mathematics course. Compartmental modeling of disease spread has been employed as an example at levels ranging from Calculus [17, pages 387–396] to Differential Equations [2, pages 209-216] and beyond. While many of these examples, and this paper, focus on models using differential equations and calculus-based techniques, some texts use difference equations and a non-calculus-based approach (such as [1, pages 279-313]). Alternately, software exists (such as STELLA [14]) allowing students to simply build a flowchart, with the software computing long-term outcomes. Using difference equations in a spreadsheet, or alternately using flowchart software, activities similar to those described in this paper — linking mathematics students to real-world concerns about disease outbreaks — can take place in courses for students with no calculus experience, such as courses in quantitative literacy or liberal arts mathematics.

As a final note: while assembling this essay we (Figure 4) recognized that we were unintentionally affirming the Mathematics and Rhetoric disciplines as discrete subject areas by discussing each in turn. As edits continued, we moved toward a more unified presentation of this shared activity. We hope that as scholarship and teaching increasingly draw simultaneously from different disciplines for the critique and production of knowledge, a new and transdisciplinary language will emerge.

References

[1] Elizabeth S. Allman and John A. Rhodes, *Mathematical Models in Biology: An Introduction*, Cambridge University Press, New York NY, 2004.

[2] Paul Blanchard, Robert L. Devaney, and Glen R. Hall, *Differential Equations, fourth edition*, Brooks/Cole Cengage Learning, Boston MA, 2012.

[3] Debra T. Bourdeau and Beverly L. Wood, "What Is Humanistic STEM and Why Do We Need It?," *Journal of Humanistic Mathematics*, Volume **9** Number 1 (January 2019), pages 205-216, doi:10.5642/jhummath.201901.11. Available at `http://scholarship.claremont.edu/jhm/vol9/iss1/11/`, last accessed on July 14, 2019.

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[1]This became immediately apparent in Fall 2014 when our Ebola activity intersected in an all-too-realistic way with the real-time outbreak that reached the United States.

Figure 4: Professors Kelley-Romano and Greer conferring on Crisis Day 2016. Photo by Phyllis Graber Jensen.

[4] Fred Brauer and Carlos Castillo-Chavez, *Mathematical Models in Population Biology and Epidemiology, second edition*, Springer, New York NY, 2012.

[5] Nicholas F. Britton, *Essential Mathematical Biology*, Springer, London, 2003.

[6] Jay Burns, "Slideshow: Presidential politics vs. (not-real) smallpox crisis, hour by hour," *Bates News*, November 4, 2016, available online at http://www.bates.edu/news/2016/11/04/slideshow-presidential-politics-vs-not-real-smallpox-crisis/, last accessed on July 11, 2019.

[7] Lauren E. Cagle, "Becoming 'forces of change': Making a case for engaged rhetoric of science, technology, engineering, and medicine," *Poroi: An Interdisciplinary Journal of Rhetorical Analysis and Invention*, Volume **12**, Issue 2 (2017), doi: 10.13008/2151-2957.1260.

[8] Rita Capezzi and Christine Kinsey, "Joining 'the mathematician's delirium to the poet's logic': Mathematical Literature and Literary Mathematics," *Journal of Humanistic Mathematics*, Volume **4** Number 2 (July 2014), pages 67-82, doi:10.5642/jhummath.201402.07. Available at http://scholarship.claremont.edu/jhm/vol4/iss2/7/, last accessed on July 14, 2019.

[9] Steve Collins, "Bates students talk about their exploration of presidential elections," *Sun Journal*, November 17, 2016, available online at http://www.sunjournal.com/bates-students-talk-exploration-presidential-elections/, last accessed on July 11, 2019.

[10] David J. Depew and John Lyne, "The productivity of scientific rhetoric," *Poroi: An Interdisciplinary Journal of Rhetorical Analysis and Invention*, Volume **9**, Issue 1 (2013), doi: 10.13008/2151-2957.1153.

[11] Leah Edelstein-Keshet, *Mathematical Models in Biology*, Random House, New York NY, 1988.

[12] Noel K. Gallagher, "At Bates College, students feel the heat of presidential campaign," *Portland Press Herald*, October 31, 2016, available online at https://www.pressherald.com/2016/10/31/at-bates-college-these-students-get-mock-star-treatment/, last accessed on July 11, 2019.

[13] Meredith Greer and Ella Livesay, "Mathematical epidemiology goes to college," *Math Horizons*, Volume **25** Number 3 (2018), pages 8-11.

[14] isee systems, home page; available at https://iseesystems.com/, last accessed on July 11, 2019.

[15] The Mathematical Association of America, *2015 CUPM Curriculum Guide to Majors in the Mathematical Sciences*, 2015. Available at https://www.maa.org/sites/default/files/pdf/CUPM/pdf/CUPMguide_print.pdf, last accessed on July 11, 2019.

[16] David Meredith, "Teaching with a Humanist," *Humanistic Mathematics Network Journal*, Issue 1, Article 5 (1987). Available at https://scholarship.claremont.edu/hmnj/vol1/iss1/5/, last accessed on July 14, 2019.

[17] Claudia Neuhauser, *Calculus for Biology and Medicine*, Prentice Hall, Upper Saddle River NJ, 2000.

[18] Linda Burzotta Nilson, *Teaching at Its Best: A Research-Based Resource for College Instructors, 4ᵗʰ edition*, John Wiley, Incorporated, San Francisco CA, 2016.

[19] Christine von Renesse and Jennifer DiGrazia, "Mathematics, Writing, and Rhetoric: Deep Thinking in First-Year Learning Communities," *Journal of Humanistic Mathematics*, Volume **8** Number 1 (January 2018), pages 24-63, doi:10.5642/jhummath.201801.04. Available at https://scholarship.claremont.edu/jhm/vol8/iss1/4, last accessed on July 14, 2019.