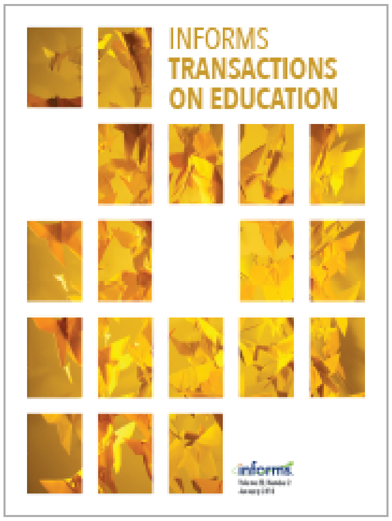

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Case Article

Dealing with the Bug in the Classrooms: Planning for a Pandemic

Ruben A. Proano
Department of Industrial and Systems Engineering, Rochester Institute of Technology,
Rochester, New York 14623, rpmeie@rit.edu

This paper describes a teaching case that can be used to introduce production control and operations management concepts by analyzing the effects of future, uncertain influenza pandemics on the day-to-day operations at a 18,000 student-body university. This case provides students with an opportunity to use key technical concepts and analytics to design a guide that can be used by school administrators to deal with future pandemics. Through this case students treat a non-traditional service environment with unclear product definition as a production system.

Keywords: pandemic influenza; production control; management science; preparedness modeling; forecasting; work continuity
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Introduction

In 2009, public and private organizations were forced to consider how the circulation of a new and potentially lethal infectious disease, the H1N1 flu virus, would affect their day-to-day activities. The virus started circulating in the Spring of 2009 and in a matter of months it spread all over the world. Similarly, to what happened in the 1918 Spanish Influenza, H1N1 particularly affected young adults, pregnant women, and people with weak immune systems. Universities and schools were among the organizations that needed to develop and implement mitigation plans to protect their students and avoid any disruption to their academic calendars. The case study describes some of the challenges faced by Rochester Institute of Technology (RIT), a private university in upstate New York, in dealing with H1N1.

Students are expected to integrate concepts in production control and operations management to help RIT design a preparedness plan for future flu pandemics that considers the uncertain effects of unknown influenza strains at its campus. In this designed case, it is assumed that RIT is primarily interested in knowing under which conditions classes should be suspended and how it should determine the resource levels required to mitigate the impact of future pandemics while trying to ensure the continuity of its services.

The case challenges students to translate their analysis into a working document that will serve as a guide for non-technical administrators. The case has been successfully used as part of a graduate level course in production control and it can be adapted to courses in logistics, operations management, and health systems engineering.

About Rochester Institute of Technology (RIT)

RIT is a privately endowed, co-educational university in suburban Rochester New York, well known for the quality of its STEM education, its co-op program, and for having more than 1,200 deaf and hard-of-hearing students supported by RIT's National Technical Institute for the Deaf. RIT's student body in 2013 consisted of 18,292 students (15,410 undergraduate, and 2,882 graduate students). Funded in 1829, the university adopted its current name in 1944. Until 2012, RIT's academic calendar consisted of four 10-week quarters followed by one week of exams and one to two weeks of recess before the beginning of following quarter: Fall (Aug–Oct.), Winter (Nov.–Mar.), Spring (Mar.–May) and Summer (June–Aug.). RIT has one of the largest cooperative education programs in the world, placing more than 3,500 students in more than 5,500 co-op assignments every year. More information about RIT is available at http://www.rit.edu/overview/.

The 2009–2010 H1N1 Pandemic

In April of 2009 the H1N1 influenza outbreak was first detected in Mexico, when hospitals were overwhelmed by an unexpected number of patients with influenza-like illness (ILI), whose health quickly deteriorated into a fatal pneumonia. In less than a month, Mexico reported more than 2,000 confirmed cases of this new type of flu. The unusual flu virus spread rapidly over the world and in a period of 2 months, 74 countries reported over 28,000 confirmed cases, and 144 deaths. On June 11, 2009, the World Health Organization (WHO) declared the state of a global pandemic (World Health Organization 2014). Public attention was intense and soon it was acknowledged that mitigation plans for the pandemic were mostly inexistent, or if available their implementation and effect on day-to-day activities were unclear. In contrast to the seasonal flu, the H1N1 virus also kept spreading during the summer months.

It soon became clear that setting up mitigation plans for the pandemic was complicated by the uncertainties surrounding the strength, lethality, and morbidity of this influenza strain. Furthermore, in the first few months it was unknown if a vaccine would be available, and if so, when and what number of doses would be needed to offer effective protection.

At the end of the sSummer of 2009 a vaccine for the H1N1 became available. This allowed universities in the United States to start vaccination programs during the Fall, which significantly contained the spread of the flu in university campuses and prevented major disruptions in their programs.

Although the H1N1 virus was highly infectious, it was not as lethal as originally expected. In its first year of circulation the virus was responsible for nearly 18,000 deaths around the world, which is less than the number of individuals dying from seasonal influenza in the United States every year. In fact, the H1N1's low mortality rate and the availability of a vaccine at the beginning of the flu season are the main reasons why the disease was contained and most mitigation plans worked well.

It is also clear that plans that worked for H1N1 may not be effective for more severe pandemics. The occurrence of a new pandemic is not questioned, it is ratter a matter of when it will happen and how lethal and infectious it will be. Had the H1N1 been as lethal as the 1918 Spanish influenza virus, most mitigation plans would have been inadequate. Even for the same 2009 H1N1 virus, if its outbreak had started in the Fall rather than in April, it would have forced universities to deal with the virus during the flu season without access to vaccines and depend primarily on their containment plans for mitigation.

Since 2010, there has been many efforts to design analytically-based plans to deal with future pandemics, and to determine the level of resources (doctors, space, vaccines, medications, etc.) required for such situations. Most of these plans have been national, state, regional or community based in scope. However, the use of analytics to overhaul pandemic preparedness plans for individual organizations has been slow, perhaps due to lower public attention levels, but also due to the organizations' reliance on the recommendations of public health authorities. However, there can be risks if individual organizations do not upgrade their mitigation plans. For example, several large universities account for a significant proportion of the populations of many communities, and hence their preparedness plans can have a major impact on local health.

A month after the global interest for H1N1 started, RIT set up an Influenza Committee (IC) that began designing plans and actions that tackle eight areas: (1) campus hygiene, (2) medicine and vaccine procurement, (3) confinement of infected students, (4) public relations, (5) capacity planning of the medical center, (6) class disruption, (7) food and wastage logistics during the pandemic, and (8) class suspension. The committee received complete support from the administration, and was able to effectively coordinate and implement its plans until the pandemic influenza was contained.

The case study describes in detail the plans and actions taken by the Influenza Committee to illustrate the impact that H1N1 had on RIT's campus life. Additionally, it describes the limitations and challenges that the committee was not able to address at the time and that could have resulted in ineffective actions, if the disease had been more severe.

Classroom Experience

The case was designed to be used as a course-long project with two sets of deliverables: Parts 1 and 2. In Part 1, students are asked to analyze the actual number of patients with influenza-like symptoms reported to RIT's Health Center between Fall 2009 and Spring 2010, and question the use of traditional forecasting to deal with a pandemic influenza. The goal of this deliverable is to strengthen students' understanding of forecasting, its limitations for dealing with an uncertain event, and its role on a production system. Typically students respond to Part 1 by simply fitting a forecasting model in the provided data, but for dealing with a pandemic (i.e., caused by a new virus) such application of forecasting is meaningless and impractical. The intrinsic assumption made by students who simply try to use forecasting to predict the behavior of future pandemics is that the mechanisms describing H1N1 will be the same for new pandemics, and that is clearly incorrect. Part 1 is effectively used to surprise students by making them realize that for a pandemic, using traditional forecasting tools is not effective.

After students submit their analysis for Part 1, a two-class discussion is needed to challenge the unquestioned application of forecasting, debate whether forecasting modeling can be used for influenza pandemic, and the role of logistics in mitigating a pandemic. In the first class of the discussion, students are questioned how they would use forecasting to support decision makers during a pandemic, and whether the bases of time series forecasting can be applied to historic pandemic data. After this first class students tend to reconsider their submission for Part 1.

The second class of Part 1 discussion offers the opportunity to discuss what compartmentalized epidemiological models are and how they differ from time series forecasting models. The template spreadsheet provided with this case (available as restricted instructor materials at https//www.informs.org/IOL-Home/Pubs/ITE/Access-Restricted-Materials) can be used to illustrate the simplest compartmentalized model (SIR), and how the number of new infected individuals per week (I_t) is affected by different disease characteristics. Through a series of questions students are lead to understand the logistical implications of controlling the number of new infections per week. At the end of the class, students comprehend the strategic importance of reducing the peak of infection, and of delaying its occurrence as much as possible into the summer months.

Part 2 of the case challenges students to design a preparedness plan that addresses the following concerns:

- Under which conditions should RIT suspend classes?
- How many beds and how much space should RIT set aside, if patient isolation is recommended for those with ILI (influenza like symptoms)?
- What is the number of doctors and nurses on staff needed at the university's health care center during a pandemic?
- What level of antivirals should RIT stockpile (if allowed)?
- What level of masks and gloves should RIT stockpile?

Students are encouraged to use compartmentalized epidemiological models to mimic influenza spread for different scenarios, which must be defined not only to cover a broad umbrella of potential influenza strains (i.e., with different morbidity and mortality) but also to reflect the effect of potential policy recommendations and the uncertainty associated with of when vaccines will be available. Students are encouraged to propose recommendations that can reduce the peak of the potential number of infected individuals during the school year, and which will move such peak towards summer months. For completing Part 2, students need to explore the literature of compartment epidemiological models, whether such models can be considered forecasting tools, and their limitations. Students must adapt a compartmentalized model to account for the effect of vaccination to obtain valid information for their analysis; and they need to make assumptions about missing information for their scenario analysis. Initially, the open-ended nature of the scenario analysis puzzles students, but as soon as they start working on the case they realized that in a real situation they would also have to make similar assumptions as most of the information would be unavailable, inexistent, or inaccurate.

Students tend to put significant amount of work in modifying the compartmentalized model needed to complete Part 2, so it is important to remind them that the key deliverable of the case is to generate an analysis that can be translated into a non-technical guide for administrators, and that it can be used to respond to future influenza pandemics. The notion of having a working guide forces students to consider the context and process in which their reports will be utilized, how data will be retrieved, how to tone and simplify their recommendations, and how to explore what-if situations.

Over the years, the reception of this case has been highly positive. Students enjoy the fact that traditional course material of production control can be adapted to such a unique non-production setting. The notion that in production control one must use data to plan and coordinate the use of resources to ensure meeting demand (and prevent a disruption in supply) is the same notion present in a pandemic mitigation plan that seeks to protect individuals and maintain continuity of services under uncertainty.

The key to successfully implement this case during a semester is to tailor its deliverables to the type of students enrolled in the course and their expectations. At RIT this course has been taught to students who have taken at least one previous course in optimization and have a working knowledge of probability and statistics. This case has been used as part of a graduate course in production control for industrial engineering students that covers the process and the analytic methods used to produce goods and services in support of production and operations management functions. The course is organized in five thematic modules: forecasting, aggregate planning, master scheduling, entreprise resource planning systems (ERP), and lot sizing models (deterministic and stochastic). Additionally, the course emphasizes the role of mathematical optimization and modeling to support production planning.

However, this case is not restricted to engineering graduate students, it could also be used as part of undergraduate engineering courses in production management, and in business courses for students interested in operations management. In these courses, the instructor could assign solely Part 2 of the case and use Part 1 to facilitate a class discussion prior to the case assignment. Additionally, for courses in which students have limited technical background the instructor could facilitate the case implementation by providing the class with a complete spreadsheet implementation of the compartmentalized model (e.g., SEIR) required in Part 2. For a non-technical audience deliverables could be changed so that the emphasis is not on quality of the analytical effort behind the student's recommendations but on the quality of the arguments and the systemic approach used to identify and support potential response strategies. Overall the case provides several opportunities to design a process to respond to uncertain and potentially disruptive effects.

The teaching guide (available as restricted instructor materials at https://www.informs.org/IOL-Home/Pubs/ITE/Access-Restricted-Materials) provides a more thorough description on how to use the case and how to adapt it to undergraduate courses in engineering and business schools. The teaching guide also provides a helpful description to facilitate the instruction of compartmentalized models.

Conclusion

The use of this case provides instructors with an opportunity to handle an open-ended situation that can help foster creativity and collaboration among students. The case requires students to make assumptions, use technical tools, design experiments to collect data, and infer policies and recommendations that are robust and can be easy to follow. Independent of the quality of the students' recommendations, several learning outcomes associated with a mature use of technical tools can be achieved through this case. Dealing with uncertainty is not new in academia, but unfortunately its instruction has been often associated with the use of complex and impractical models. This case is helpful to bridge this instructional gap by giving students the opportunity to experience the difficulties of applying mathematics and analytical tools for a realistic decision-making situation where having clear and usable recommendations is of extreme importance.

Supplemental Material

Supplemental material to this paper is available at http://dx.doi.org/10.1287/ited.2016.0156ca.

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