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Virtual Epidemics as Learning Laboratories in Virtual Worlds

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Abstract

In this article, we put forward the proposal to use virtual epidemics as learning laboratories for players to develop a better understanding of infectious disease, its social implications, and inquiry process. In the case of virtual epidemics, players can use their own experiences and observations of the community to learn about processes of infection and immunity, the interactions of social behavior, and reactions to perceived health risk – investigations difficult to replicate in real life due to ethical considerations. Different learning laboratories can engage students in testing different parameters in epidemic simulations, identifying and developing vaccines, analyzing archival records of past epidemics, and discussing ethical issues. Such laboratories would allow students to become epidemiologists using the very same tools that professional scientists now use to

model and study the outbreak of an infectious disease. These are not unreasonable expectations given prior experiences with the virtual epidemic Whypox in Whyville.net, a large-scale virtual world with over 2 million youth ages 10-12 years. This article reviews past research findings and outlines new approaches for students in K-12 education to learn about and with virtual epidemics.

Keywords: virtual epidemic, science inquiry, ethics, virtual laboratories

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It is only recently that the learning potential of virtual worlds has moved into the focus of public attention (Bainbridge, 2007). While virtual worlds have been in use for many years (Gee, 2003) the unplanned virus outbreak in the World of Warcraft™ became a story in the mainstream news media (Ward, 2005) and then a case study for epidemiologists (Lofgren & Fefferman, 2007). Lofgren and Fefferman argued that virtual epidemics were more than just a game: they could help us learn about human behavior in real epidemics – research difficult to replicate in real life due to ethical considerations. Virtual viruses can simulate many aspects of real life outbreaks, in some instances even seemingly 'deadly' consequences when a player avatar loses its accumulated powers and resources and has to start all over again. While death in cyberspace does not equal death in real life, to players the consequences were real in terms of actual time, social capital, and dollars spent on having their avatars reach certain levels.

In this article we want to take the idea of virtual epidemics a step further by promoting them as learning laboratories for students to develop a better understanding of infectious disease, scientific inquiry, and social impact of infection-related behavior. Our goal is to illustrate how interventions such as virtual epidemics that impact both the community and the individual player can create authentic learning opportunities or laboratories. We characterize these learning laboratories as 'authentic' because professional epidemiologists now use virtual epidemics as a way to identify pertinent factors for modeling real-life behavior (see Exhibit 1). As a case in point, we use the outbreak of a virtual epidemic called Whypox in Whyville.net, a tween virtual world. We first provide first background on research in virtual worlds and learning about infectious disease, then describe the 2005 Whypox outbreak in which we gathered information about participants' online interactions and personal experiences, and finally discuss a series of learning laboratories that can serve

as models for other educational interventions in informal spaces with possible bridges into science classroom activities.

Exhibit 1

Whypox from the Perspective of an Epidemiologist: Virtual Epidemics as a Research Laboratory

Virtual epidemics have equal importance for advancing the science of epidemiology. Epidemiologists have used computer-based modeling for a long time to predict and understand patterns, examining the role individual- and group-level susceptibilities, behaviors and mitigation strategies each play in determining disease dynamics in a population (e.g. Eubank et al., 2004; Sattenspiel, & Carpenter 2004). While these computer models have allowed very detailed investigation of the epidemic outcomes of assumed human behaviors, they have relied on basic assumptions about human reactions in situations of health risk from infectious agents which are difficult to measure (Fenton, Johnson, McManus, & Erens, 2001). By engaging human players, known to become emotionally invested in their virtual communities, in analogous situations of communal health risks, epidemiologists can begin to design experiments to tease apart how people really react to such threats in ways that would be impossible to achieve in real-world experiments. Virtual epidemics like Whypox can provide some insights into behaviors previously unconsidered in epidemiological modeling, even without the benefit of designed experimentation. For example, players who undertook personal risk in order to satisfy curiosity were observed during the World of Warcraft outbreak – these behaviors had not before been explored epidemiologically, but do have the potential to drastically affect the overall risks of disease spread.

Using the a virtual epidemic like Whypox as a basis for such experimental designs will still involve an initial period of validation and testing of a model developed for real-world epidemiological prediction. For instance, existing models need to be tailored to represent virtual world interactions, durations of contact, in-world transportation and movement, and consistency of friendship groups as well as the etiology of the Whypox itself. It also would need to be tested whether or not the existing epidemiological models do achieve accurate predictions of within-Whyville disease dynamics. This will be of great importance when determining the scope of interpretation of resulting infection outcomes to broaden a general epidemiological understanding. It is likely that altering the Whypox itself to more closely mimic specific aspects of real-world disease etiologies will allow more controlled experiments, and more accurate model outcomes and predictions, and therefore more ease in accurate interpretation for broader use.

It is also necessary to manipulate further the existing Whypox to permit concept validation within the virtual world. A greater diversity of relevant etiological and epidemiological parameters,

such as infectivity, severity of symptoms visible to others, and mechanism of transmission of infection, will allow epidemiologists to design a full series of controlled experiments exploring the reactions of individuals to diseases that differ in precisely controlled and defined ways. Since diseases in the real world frequently differ in more than one aspect from each other, it is difficult to know which specific characteristics are inciting which reactions in the population. By controlling the strains of Whypox in this way and observing the differences in responses, researchers can begin to better understand human reactions to disease. Further, they can explore the roles played by education, rumors, media reporting, and public health initiatives at shaping or mitigating those responses.

Finally, epidemiologists can observe relative transmission rates and numbers of Whyville inhabitants ultimately infected by the different strains of Whypox. Since they will have complete knowledge of the purposefully designed epidemiological parameters, they will be able to tease out the direct impact of the observed behaviors on the outbreak dynamics and determine which social, environmental and disease-related characteristics were most influential at altering individual and group behaviors in response to disease threats. These types of questions are of critical importance when making public health decisions, and can be uniquely addressed in virtual worlds because of the complete availability of use and interactivity data.

Learning in Virtual Worlds

Our proposal of developing learning laboratories builds on previous research of computer-based tools and virtual worlds for learning about various aspects of infectious disease. While wearable or handheld computer applications have been designed for students to experience short-term simulations of epidemic outbreaks in classroom settings (Colella, 2000; Hug, Krajcik, & Marx, 2005), virtual worlds have extended these investigations in time length, complexity, and number of participants by creating large-scale, graphic, and real-time simulations. This emerging field is led by developments of Quest Atlantis (Barab, Arici, & Jackson, 2005), RiverCity (Dede, Nelson, Ketelhut, Clarke, & Bowman 2004), and Whyville (Neulight, Kafai, Kao, Foley, & Galas, 2007). Most pertinent is research on the virtual world River City where students learn about the process of scientific inquiry by examining the sewer system and housing conditions in the 19th century, simulating some of the first functional epidemic control models in public health (Snow, 1855). Students use their avatars to interview the city's virtual inhabitants and collect data about sanitary conditions within the city but the avatars did not experience the diseases themselves. Studies have shown that previously low-performing students are more motivated to learn about the scientific process (Nelson & Ketelhut, 2007). In Whyville.net, players create avatars who experience an

outbreak of a virtual epidemic called Whypox over several weeks. When students participated in Whypox as part of their sixth grade science curriculum on infectious disease, they learned to draw comparisons between real life and the virtual epidemics in classroom discussions (Neulight et al., 2007). These initial findings prompted us to investigate online activities and experiences in a virtual epidemic – described in the following section in more detail.

Design of and Experience in a Virtual Epidemic

Whyville.net is a massive virtual world with currently over 4.2 million registered players ages 8-16 years. Until 2007, an annual outbreak of a virtual epidemic called Whypox impacted the whole community; now Whypox is a permanent part of Whyville life. Whypox, then and now, is a virus created by the company who hosts Whyville and usually launched at a public area of the virtual world visited by many players. Its mechanism of disease transmission can vary in type such as chatting or mailing with someone infected, getting hit with a projectile from an infected person, or just being in the same place as other infected people, as well as in the likelihood of getting infected and in visible manifestations. While players do not know what the actual mechanisms of disease transmission are, it leads them to articulate theories about possible causes and progressions of Whypox.

When Whypox hit Whyville in the early winter of 2005, it had an immediate effect on Whyvillians, largely because it manifested itself in the two most popular activities: avatar looks and social interactions with others. The first symptom of Whypox is the appearance of red dots on one's avatar. The second symptom is the random interruption of chat and replacement of typed text with "Achoo." While these features of Whypox may at first seem funny or a nuisance, they interrupt valued social functions and activities. We found that multiple aspects of Whyville life were impacted by Whypox that indicate its perceived relevance: visits of the Whyville CDC, a virtual Center for Disease Control (not associated with the real one), uses of epidemic simulator, writings in the online newspaper, and personal reactions to the lived experience.

Our information is based on a 2005 study (Kafai, Feldon, Fields, Giang, & Quintero, 2007) in which we recruited 438 online Whyville players between ages 10 and 16 years and surveyed them about their science and technology interests, Whyville activities, and understanding of Whypox. We also tracked their online movements and chat interactions

before, during, and after the Whypox outbreak. In addition, we conducted a content analysis of writings about Whypox published in the weekly online newspaper The Whyville Times.

The virus spread fairly quickly and within three days of its launch, incidence of the disease had peaked and infected more than 4000 community members. We know from our tracking data that visits to the Whyville CDC before the outbreak of Whypox are close to non-existent with the exception of the occasional curious peek or accidental visit. This all changed once Whypox arrived: the number of visits jumped to 5,386 in a two-week window. The Whyville CDC features an archive with information about previous infections and a bulletin board where players posted hypotheses about the causes of Whypox and its etiological characteristics. Within these postings, most Whyvillians agreed that people got better within two weeks, but there was greater variety in their speculation about how Whypox was spread. The majority of suggested mechanisms of infection mirrored those types of interactions commonly assumed by the public in real-world epidemics, even in the absence of scientific evidence. Others thought you became infected from the sun or not wearing warm clothes when it was cold outside. The process of postulating these causes and effects, and comparing them to observed or reported case histories is the same exploratory process employed by both members of the worried public and professional epidemiologists during the early stages of any outbreak.

We also found preliminary evidence that Whyvillians use experimental simulations to test hypotheses about rates of infection and epidemiology. Within the Whyville CDC, simulators let participants set and test different parameters for the rate and duration of infection. We observed that the frequency of the epidemic simulator use peaked during the Whypox outbreaks: over 1,400 simulations were performed by 171 of the 438 online players who participated in a study. We saw that 116 of them engaged in some form of more systematic investigation by running the simulations three or more times and half of them demonstrated significant improvements in the accuracy of their predictions (Feldon, & Gilmore, 2006).

At the same time that Whypox was peaking, articles begin to appear in the Whyville Times. In the February 6, 2005 and February 13, 2005 issues, when Whypox was the most prevalent, 3 of 20 and 5 of 21 articles, respectively, appeared in the weekly issues. In these articles, Whyvillian authors discussed when and where they discovered Whypox, theories for how it was transmitted, and even a scam where some Whyvillians “offered” to heal those infected if only they would be given passwords to accounts so that they could use their “computer genius” to cure people. Interestingly, many articles reported discovering Whypox

in one place and thought it might be a joke, but then realized something different was happening when they found the effects to be more widespread. As one author described it: "Other times before this morning, people would go around faking the Whypox and saying Achoo. I played along this morning, fake sneezing like everyone else. But little did I know, they were sneezing beyond their control." Many Whyvillians felt that Whypox was like a real infectious disease, citing its contagious nature as the most realistic feature. These very aspects of Whypox made it an integral part of Whyville community life; they also provide the foundation for considering virtual epidemics as a context for learning laboratories.

Virtual Epidemics as Learning Laboratories

Based on these developments and our initial observations, we contend that a virtual epidemic like Whypox can offer promising opportunities for participants to design and implement empirical experiments that investigate human response to social, infectious risks. Participation in Whypox will offer players a first hand experience with an epidemic outbreak because it provides an authentic context for studying communicable diseases that cannot be replicated in life for ethical reasons. We envision the following observatories, simulators, archives, and public panels as examples of such learning laboratories.

Observation Lab

To begin with, virtual epidemics allow for valuable scientific inquiry by observing the behaviors of oneself and other Whyvillians during the epidemic outbreak. We can provide tools for visualizing various aspects of this outbreak in the larger community. For instance, one graph could showcase the daily tally of infected Whyville players, thus providing a quantitative and longitudinal overview of its impact, while another graph could display the number of infected players at various locations in Whyville and thus reveal centers of concentration. Other graphs could show all active strains in the infected population of Whyville, and visualize their distribution across different popular Whyville location. Finally, content of public chat could be fed into tag crowds that indicate the major topics of conversations among Whyvillians. Visualizations of this type are easily embedded in Whyville and accessible in any Internet browser. Players' interpretations of visualizations could be posted in discussion forums where other players' ratings of the content could provide prompt feedback and a form of peer assessment. In addition, such feedback could

assist students who often have issues in interpreting complex visualizations. Other forms of assistance could be provided in sidebars or short tutorials or in offline classroom discussions.

Simulation Lab

Virtual epidemics also allow for valuable scientific experimentation by providing simulators that allow players to test different scenarios. Here players could test different parameters of an epidemic by running controlled scientific experiments to answer narrowly defined, specific questions about the influence of individual factors within a multifactor, complex biological system. Such simulators allow for formulating, testing and subsequently rejecting or accepting a hypothesis – key features of the scientific inquiry process. In addition, such online simulations allow for embedded assessments as students' growing accuracy in predictions could be used as a measure for their better understanding of salient features. The combination of observed and hypothetical behaviors offers intriguing opportunities to help players understand the idea of using inferred relationships from observed data to make predictions about future, unknown outcomes for use in decision making for public policy. While students' issues with hypothesis formulation and testing have been documented in the research literature, offline support in form of teacher questions and feedback and online support in form of discussion forums could provide much needed assistance and help integrate these activities into the science classroom curriculum (Linn & Hsi, 2000).

Vaccine Design Lab

Whyville can provide virtual laboratories in which players identify the strain of Whypox virus with which they are infected and then design a vaccine that might protect them against future outbreaks. This approach would also emulate current flu vaccine design where researchers try to identify and predict strains that will be prevalent in the coming season and in particular geographic regions. While such approaches are not feasible in current school laboratories due to the lack of equipment, these online versions can engage students in equivalent processes of detecting patterns in strains and designing appropriate vaccines.

Archive Analyses Lab

With Whypox, we also have the unprecedented opportunity to add a historical context to the study of virtual epidemics. From 2001 to 2007 Whypox was a seasonal event often concurrent with the outbreak of the flu season. The Whyville CDC contains an archive of the

early Whypox outbreaks documenting players' experiences and theories about the causes and spread in discussion boards, community newspaper articles, and graphs. Students can use these materials to study patterns and experiences of past outbreaks, engage in comparative analyses, and make predictions about current outcomes. While many young players do not have extensive experience in learning with primary sources, previous research suggests that even elementary students can understand and use sourcing strategies (Kafai and Gilliland-Swetland 2001)

Public Panels in the Ethics Lab

Finally, we know from the reactions of Whyville players that fear of infection impacted player behavior during the outbreak ranging from ostracism to players expressing interest in getting infected. The social ramifications of prevention, protection, and interaction with others provide an authentic context for players to discuss ethical issues associated with vaccination, quarantine measures, and public health. For instance, appropriate measures can be taken within the community to control the spread of disease in ways that blanket, non-specific measures may not be able to achieve. Participation in un-monitored online discussion boards can at times be problematic because players might veer off topic but seeding discussions with prompts or questions can help focus postings.

These learning laboratories are a first proposal for dedicated spaces in virtual worlds that provide a more in-depth investigation and understanding of lived experiences in virtual epidemics. One popular form of assessment in massive communities is crowd-sourcing in which virtual world participants rate contributions and hence provide feedback about their value to other players. Other forms of feedback and assessment are summaries of activity logs that inform teachers whether students have participated in essential activities. Researchers are just beginning to develop assessment tools for virtual worlds, in particular those that can leverage the analyses of player behaviors and interactions in an efficient manner (Ketelhut, Schifter, & Nelson, 2008).

By observing and participating in Whypox, simulating the infection rates and other parameters, investigating the history of virtual epidemics, and discussing ethical and social concerns, we can engage youth in understanding key aspects of infectious diseases and epidemics that are a central part of living systems in the Grade 5-8 science curriculum. Moreover, virtual epidemics as proposed offer an integrated approach because historical, social and ethical considerations are all part of scientific inquiry. By providing experience at all three levels of the scientific process of investigative epidemiological research,

Whyvillians will gain a direct understanding of the processes of infectious disease in populations, but importantly, they will also see how applied scientific research can provide recommendations for action to protect the public.

Conclusions

Our proposal of virtual epidemics offers a new model for learning in virtual worlds because it leverages particular design features of virtual worlds: real time, personal representation, and massive numbers of players. The idea of learning laboratories moves beyond the recognized value of virtual laboratories and thus could be more easily adopted by commercial virtual worlds. Participation in and study of virtual epidemics offer an authentic context within which to become familiar with the need for, and practice of, these aspects of empirical experimentation, one that is not only familiar but also of personal relevance as virtual worlds have become the new meeting place for youth. By bringing the mindset and tools of epidemiologists to virtual epidemics, we offer a viable approach for youth to become engaged in science and provide them with new lenses to understand the virtual worlds they inhabit.

Given the millions of players in virtual worlds, the success of our design could make virtual epidemics accessible to thousands of learners in classrooms, afterschool clubs and homes. Most importantly, virtual epidemics provide a test bed for youth to experience and understand issues about communicable diseases and vaccination that are at the forefront of today's public debate. Public health prevention and protection measures are connected to behavioral changes and conceptual understanding of infectious processes and interactions. It is here where a better understanding of epidemic dynamics, real or virtual, can have a broader impact on personal and societal health.

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