What Happens if you Catch Whypox? Children's Learning Experiences of Infectious Disease in a Multi-user Virtual Environment

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ABSTRACT
This study investigated students' understanding of a virtual infectious disease in relation to their understanding of natural infectious diseases. Two sixth grade classrooms of students between the ages 10 to 12 (46 students) participated in a participatory simulation of a virtual infectious disease as part of their science curriculum that took place in a university-laboratory school in Los Angeles, California. The results from our analyses revealed that the immersive components of the simulation afforded students the opportunity to discuss their understandings of natural disease and to compare them to their experiences with the virtual disease. We found that while the virtual disease capitalized on students' knowledge of natural infectious disease through virtual symptoms, these symptoms and a missing curricular piece of computational viruses may have led students to think of its transfer more as an observable or mechanical event rather than as a biological process. These findings provide helpful indicators to science educators and educational designers interested in creating and implementing such online simulations to further students' conceptual understanding.

Keywords
multi-user virtual environment, science education, simulation

BACKGROUND
Teaching students about the dynamics of infectious disease has taken many forms (e.g., textbook, video, hands-on experiments). More recently, researchers have started investigating various forms of participatory simulations of which multi-user virtual environments (MUVEs) are a subset. MUVEs enable thousands of participants to simultaneously access a virtual world on the Internet [1, 4, 5, 7]. This report investigates the learning about infectious disease within a

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MUVE, called Whyville.net, when a virtual disease called Whypox spread through this online community. This investigation was guided by the following research question: How do students' experiences of a virtual epidemic such as Whypox help them understand natural diseases? We predicted that a virtual disease such as Whypox could help students understand the causes for disease spread. Research has shown that children have difficulty with these concepts, in particular the concept of contagion [3, 8-13].

The disease simulation occurred when Whypox infected the online community of Whyville, (http://www.whyville.net), which had over 400,000 registered users at the time of this study. Avatars who contracted this virtual infectious disease presented themselves with red dots appearing on their faces and their chats being interrupted by sneezes – two key features of Whyville community life. The simulation Whypox draws inspiration from other participatory simulations that teach about infectious disease [6, 14, 15]. Several features of participatory simulations are of instructional relevance for learning about infectious disease: first, the ability of learners to create avatars who can be immersed in disease experiences without direct physical harm to the participant which would be difficult to replicate in real life due to ethical considerations; the ability to simulate real time the experience of infectious disease spread within a large community; lastly, the ability to simulate the real time duration of disease spread over several weeks unlike some previous participatory simulations [6, 14].

METHODS

Before and after the curriculum unit on infectious diseases, the survey on natural infectious diseases was given to all students by the researchers. The Whypox survey was only administered at the end of the unit. All classroom sessions were videotaped. One to two researchers of a team of five administered the assessments and videotaped.

Participants

Participants were 46 sixth-grade students between the ages 10 to 12 in two science classes taught by the same teacher in a laboratory school comprised of a diverse ethnic sample and affiliated with a large urban university in Los Angeles, California.

Classroom Activities

The use of Whyville was integrated into a 10-week teacher-led curriculum about infectious diseases. Some of the activities that students participated as part of their science curriculum included: watching videos about specific diseases and the nature of germs; examining cell structures under the microscope; doing hands-on experiments that simulated the spread of an infectious disease; completing worksheets about cells, bacteria, and viruses; and using online tools to research specific diseases. These activities took place throughout the study, even after Whyville was introduced to the students in the third week of the study. At this time, students logged on Whyville for at least ten minutes every science classroom. In addition, many students logged on at home.

Students had access to the Whyville website during school hours and after-school hours (see Figure 1). Each member of Whyville was represented by a screen name and avatar, which was a member's online headshot that appeared on the screen after a member logged on to the website. A member augmented his or her avatar by buying or creating face parts.

Figure 1: This is the homepage of Whyville.net.

To travel through Whyville, a member selected a destination from a drop down menu that was always accessible to the members or by clicking on the screen with the computer mouse. Each destination offered a different type of activity such as: science-related activities with some specifically about infectious diseases; recreational games like checkers; the *Center for Disease Control*, where members could read about past outbreaks of Whypox authored by children and science educators; and *The Whyville Times*, the website's online newspaper that included participant-authored articles about the site. Members could communicate with other participants synchronously with other members by having a cartoon chat box appear above their avatar face or members could communicate asynchronously through ymail, an internal mail system, and a bulletin board system.

During weeks three to five, students explored a variety of Whyville activities, both recreational and science-related, as instructed by the teacher. When Whypox hit Whyville during week five, the teacher facilitated whole-class discussions to discuss what was happening on Whyville, in particular the outbreak of Whypox (see Figure 2). These discussions occurred approximately twice a week for about thirty minutes each until the end of the study. In these discussions, the teacher and students created a graph on a large piece of paper that displayed on one axis the number of Whypox infections in both classes and displayed on the other axis the date of infection. They also discussed technical issues about using Whyville such as how to chat and how to participate in a certain activity. In addition to the discussions about Whypox, the teacher guided students to explore the disease-related activities on Whyville's CDC (see Figure 3). At the CDC students read about past cases of Whypox and posted predictions about causes and cures in addition to using tools that simulated outbreaks of diseases by manipulating variables such as the duration of a disease. At week ten, students were administered the post-disease survey and a survey about Whypox.

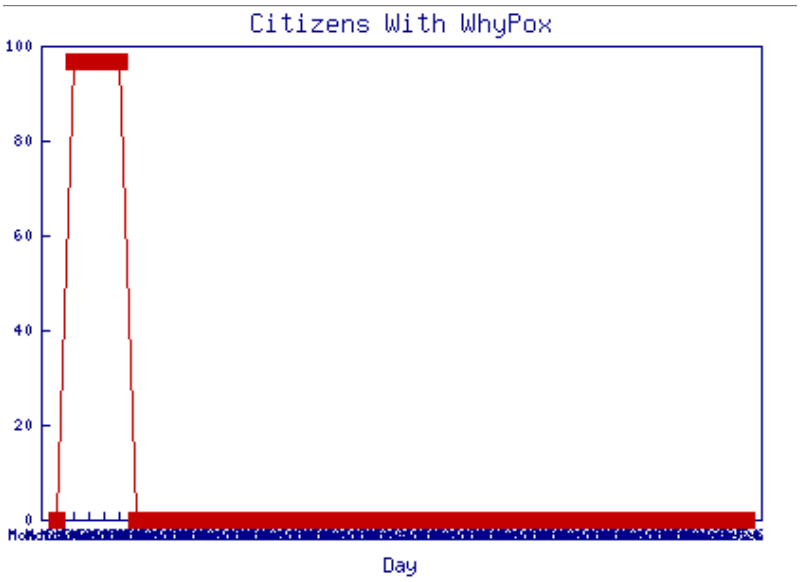

Figure 2: This is a graph that displays the intensity of Whypox outbreaks.

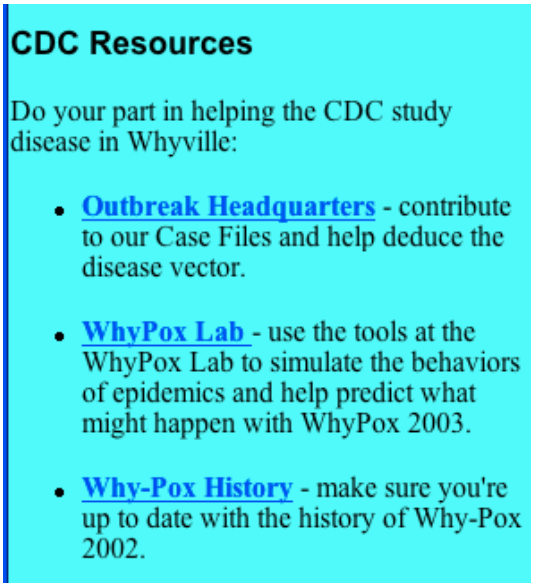

Figure 3: This is Whyville's Center for Disease Control (CDC), which features simulation tools and information about infectious diseases.

Videotapes

Video segments of whole-class discussion were examined in order to determine the efforts used by the teacher and the students to apply their Whypox experience into what really happened with natural diseases. We were particularly interested in the following aspects: the introduction of infectious disease terminology in discussions regarding Whyville, the connection between virtual and natural diseases, and the discussion of the 'immersiveness' component of the participatory simulations.

Surveys

Students' understanding of natural diseases was assessed with open-ended and scenario-based questions that focused on students' conceptual understanding of natural disease transfer. For the purposes of our study, we were interested in the questions that asked students about the causes of natural infectious disease. The following scenario from Au's (1999) study tapped students' causal mechanisms of natural infectious disease:

"Cathy went over to see her friend who was sick. Some bad germs got inside her body. She felt okay for a day. But then the next day she started to feel sick all over her whole body. Her head ached and her stomach hurt and her throat hurt – all at the same time. (a) Why did it take a whole day for her to feel sick after the germs got inside her body? (b) How did the germs make her feel sick in so many parts of her body at the same time?"

Students' understanding of Whypox, the virtual infectious disease, was assessed with a survey in order to measure whether students viewed a virtual disease with the same attributes as a natural infectious disease and to assess students' causal mechanisms of Whypox.

ANALYSIS

The first strand of analysis consisted of coding students' survey responses about natural and virtual infectious disease while the second strand of analysis examined the whole class discussions about Whypox using transcripts of the videotaped classroom discussions. To ensure intercoder reliability, two researchers reviewed the same 25% of the assessments. Only items that received at least an inter-rater agreement of 80% were used for further data analysis. We combined both classes into one data set after establishing no significant differences in students' pre-test scores.

Students' causal mechanisms of natural infectious disease were coded as pre-biological, which included transfer as an observable event (e.g., she got sick because she stayed out too long) or as mechanical (e.g., he got sick because someone coughed near him), or as biological, the most sophisticated causal mechanism, such as germs reproduced in the body after fighting white blood cells. These coding rubrics came from a previous research study [2].

Students' causal mechanisms of Whypox were coded with a similar rubric as the one for natural infectious disease but included the unique features of the virtual infectious disease. Because we viewed the causal mechanisms of the virtual disease distinctly from those of natural disease, we applied the term 'pre-computational causal explanation' as the equivalent of a pre-biological causal explanation used for natural diseases and 'computational causal explanation' as the equivalent of a biological causal explanation. Computational explanations included the mention of an embedded piece of code whereas pre-computational explanations referred only to the medium (e.g., avatar, game, face part) that carried the code and not the code itself. We analyzed students' causal explanations as computational or pre-computational because we were interested to see if at the end of the study students were more likely to provide the more sophisticated causal mechanism to explain the spread of the virtual epidemic.

RESULTS

Whypox in Classroom Discussions

During and after the Whypox outbreak, the students and the teacher discussed their

understandings of natural disease and compared them to their experiences with the virtual experiences in three ways. First, from the six hours of collected classroom transcripts we found evidence that all of the major concepts of infectious disease such as contagious, symptoms, and immunity were mentioned, if not discussed. Often the students or the teacher mentioned one of these concepts to describe an aspect of their Whypox experience. However, beyond the mere mention of the concept or term, once mentioned these concepts and terms often became woven into conversations. These conversations allowed for the students to use the terms in authentic situations to hopefully understand what they really meant. Second, students and the teacher mapped symptoms and preventions of Whypox to those of natural disease such as the plague and the cold, and vice versa. Aside from emphasizing a point, these links were used to help students make sense of what was happening with Whypox. These links of Whypox to natural infectious diseases may have helped students to think about the virtual infectious disease in ways similar to natural infectious disease. Also, some of these links may have helped students to think about the causes of Whypox with a more sophisticated causal mechanism than mere contact since students had learned through other instructional methods that bacteria or viruses were the biological causal agent of natural infectious diseases, not the contact itself. Lastly, students and the teacher used Whypox to understand natural infectious disease through immersiveness, which made reference to them as having Whypox (e.g., "I got Whypox two days ago"). These references could be an indication that students genuinely bought into the idea that they and others had the virtual disease.

Student's Understanding of Virtual Disease

In a post survey, we asked students the question "In which ways was Whypox like a real infectious disease?" Our results showed that students perceived several features of the virtual infectious disease as features inherent in natural infectious diseases. These features included being contagious (80% of the responses, n = 32), having symptoms (32.5%, n = 13), and being like a specific other disease (20%, n = 8). We asked students "How do you think Whypox spread through the community?" All of the students' explanations for virtual disease transfer included a pre-computational causal mechanism such causes as through contact, chat, and sneezing. No student attributed a computational causal explanation that included transfer of Whypox through a piece of embedded code.

Students' Understanding of Natural Infectious Disease

Based on the students' responses to the scenario-based questions about the transfer of natural infectious disease, we found that while the majority of students still reasoned with pre-biological causal explanations, there was a significant change in students' responses between pre and post from pre-biological to biological explanations ($t = -3.500$, $df = 44$, $p = 0.001$; $t = -3.496$, $df = 44$, $p = .001$).

Students were asked two open-ended questions about the causes of disease: (1) What are some of the causes of infectious diseases? And (2) What are some things that will increase the spread of the disease? Pair wise t-test analyses showed that there was significant change in students' responses to the first question ($t = -2.121$, $df = 44$, $p = .040$) and second question ($t = -2.413$, $df = 44$, $p = .020$). Students were able to provide more comprehensive responses, i.e., listing more causes, to these questions at the end than at the beginning of the study.

DISCUSSION

This study revealed some benefits as well as issues in using multi-user virtual environments to teach students about infectious diseases, a challenging task for students (Au & Romo, 1996; Bibace & Walsh, 1981; Kalish, 1999; Siegal, 1988). A virtue of using a virtual infectious disease such as Whypox was that by using avatars students experienced a disease without physical harm to their actual self, an affordance absent from traditional science curricula of instruction from textbooks, videos, and laboratory experiments.

Our results also showed that students reasoned about Whypox with less sophisticated causal reasoning than they had for natural infectious diseases. We believed that the similarity of Whypox to familiar natural infectious diseases such as chicken pox and the cold in which children and adults have naïve understandings might have accounted for some of this discrepancy. In addition, we believed that there was a missing curricular piece or computational viruses that prevented students from linking natural and virtual diseases.

These findings suggest that the design of the virtual virus needs to be tailored in particular ways to further students' conceptual understanding. The actual cause of Whypox was exposure to someone who had Whypox, which represents a pre-biological causal mechanism. Having a more biological causal mechanism of the cause and spread of Whypox in addition to the inclusion of computational viruses in the curriculum could provide a better model and experience for students.

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