Chapter 8

Virtual Playgrounds: Children's Multi-User Virtual Environments for Playing and Learning With Science

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For the last two decades, digital media have played an increasingly central role in children's play. Videogames, digital books, and robotic toys are just a few examples that have found their place along board games, story books, and dolls (Cross, 1997). More recently, multi-user virtual environments (MUVEs) have become a new genre of popular games among young players (Dede, 2004). Rather than stand-alone play devices, MUVEs present complex online worlds in which players create their online representation, assume new identities, and socialize with other players by chatting or playing online games. There are many examples, such as *Neopets*, *Whyville*, *Habbo Hotel*, and *Puzzle Pirates* that now have over millions of registered users. The number of hours spent in these worlds creating avatars, trading items, chatting, and designing homes are a sure indicator that these environments have something of interest to children that might be repurposed for educational venues.

Historical Context for MUVEs

As one of the first MUVEs researchers, Amy Bruckman (2000) investigated the instructional potential of MUVEs for learning about writing and programming. She found that the social context in her online environment, called *Moose Crossing*, provided incentive and support for players to engage in the programming of objects for others. Chris Dede investigated *Rivercity*, a historical simulation MUVE, and how its collaborative gaming features motivated science inquiry for low performing students (Dede, Nelson, Ketelhut, Clarke, & Bowman, 2004). Sasha Barab designed *Quest Atlantis* to offer a 3D virtual world in which students can participate in collaborative quests to build a community knowledge base (Barab, Thomas, Dodge, Carteaux, & Tuzun, 2005). More recently, some researchers have turned their attention to commercially available MUVEs or MMORPGs (massive multiplayer online role-playing games) and examined their potential as learning communities (Gee, 2003). Kurt Squire and Sasha Barab (2004) investigated how *Age of Empires* and *Civilizations* could be used in history classrooms to understand how players develop an interest in history, historical understandings, and school engagement. Benjamin DeVane and Kurt Squire (2006) focused on how game play in *Grand Theft Auto: San Andreas* mediates players' understanding of culture, race, and violence, and the resulting implications for educators. Constance Steinkuehler (2004) examined how participation in *Lineage* created habits of mind traditionally associated with science inquiry. The outcomes in all of these investigations indicated that playing these games is more than just fun and provided evidence of rich opportunities for improving motivation and learning academic, and social skills.

We have chosen to focus on the implications of a MUVE, called Whyville.net, that offered both science play and learning activities in their online world to thousands of players. Unlike *Rivercity* or *Quest Atlantis*, *Whyville* was not designed for a classroom context or a specific instructional purpose. Players come to Whyville on their own volition and time, and have the option, but not the obligation, to engage in a variety of science topics. Access to Whyville is free and open to anybody with an Internet connection. Whyville also differs from many of the existing online science education efforts because it is primarily an informal learning experience. Unlike the occasional museum visit, kids can visit Whyville with greater frequency, at all hours of the day, and stay for hours at a time to engage extensively in topics of their choosing.

Our chapter will present an analysis of different activities available in Whyville, in particular casual, collaborative, and community science-related games, and the potential they hold for science inquiry in informal settings. In our evaluation, we were interested to find out where players spend their time and to what extent they become engaged in Whyville's various science games. We worked with two classes of sixth-grade students aged 10–12 and asked them about their activity preferences in Whyville at different time points during their three months online at school and at home.

Getting around in Whyville

Whyville provides its players, called Whyvillians, with dozens of different places to visit and opportunities to learn about science at the individual to the community level. When a Whyvillian logs onto their account, they immediately arrive at the Welcome Page with links to events for the week, Whyville Times newspaper articles, survival tips, and FAQs. Upon arrival, users can also check their personal email (called ymail), status on their Whyville salary, and whether new mail with clam attachments, called y-grams, have arrived. Whyville has an active community life which elects its own mayor, organizes annual virtual proms, and posts many public petitions that campaign to include or change features of Whyville (see Figure 8.1).

Whyville also allots plenty of opportunities for online social interactions such as chatting, whispering, and sending ymail to others. When they login, Whyvillians may head straight to the sun roof, pool party, and other locales to chat with friends and other users. Some of these locales are connected or next to science activity games. For instance, the sun roof is the top of the sun spot building site, where users can play games related the sun's location, path, and time. Places such as the trading post allow Whyvillians to exchange goods. Others were merely created as social locales to encourage online interactions. Chatting content focuses on topics related to school, friendships, and appearance. While chatting is public (see Figure 8.2), Whyvillians can also whisper to each other, in which case only the designated person gets to see the question and can choose to reply in private or public. Another popular form of socializing is to organize parties at one's online house.

To navigate through the site, each user account has its own personalizable avatar (see Figure 8.3). At the initial sign-up, each player gets assigned an oval with eyes and a mouth but no other distinguishing features. New players can go to Grandma's for donations of free face parts or purchase them at Akbar's Mall, which lists and sells thousands of different hair parts, lips, eyes, mouths, accessories, and even animated parts. All these parts are created by other Whyvillians who rent design tools and then post their creations at the mall or exchange them at the trading post to cover their costs and as a source of income. To compose your avatar is called "picking your nose," and some Whyvillians are known to change their appearance several times during their login. To pay for the change in appearance of their avatar, Whyvillians have to earn a salary in clams, the virtual monetary unit, by completing an assortment of science-related activities, participating in events, contributing articles to the Whyville Times, and so on. Many articles submitted to Whyville Times are science related, address ways to promote social interaction via science-related games, discuss the Whypox epidemic (a virtual infectious disease, discussed later), among other topics. The bulletin boards along with the Whyville Times provide places for users with similar likes to discuss various (science and non-science-related) topics.

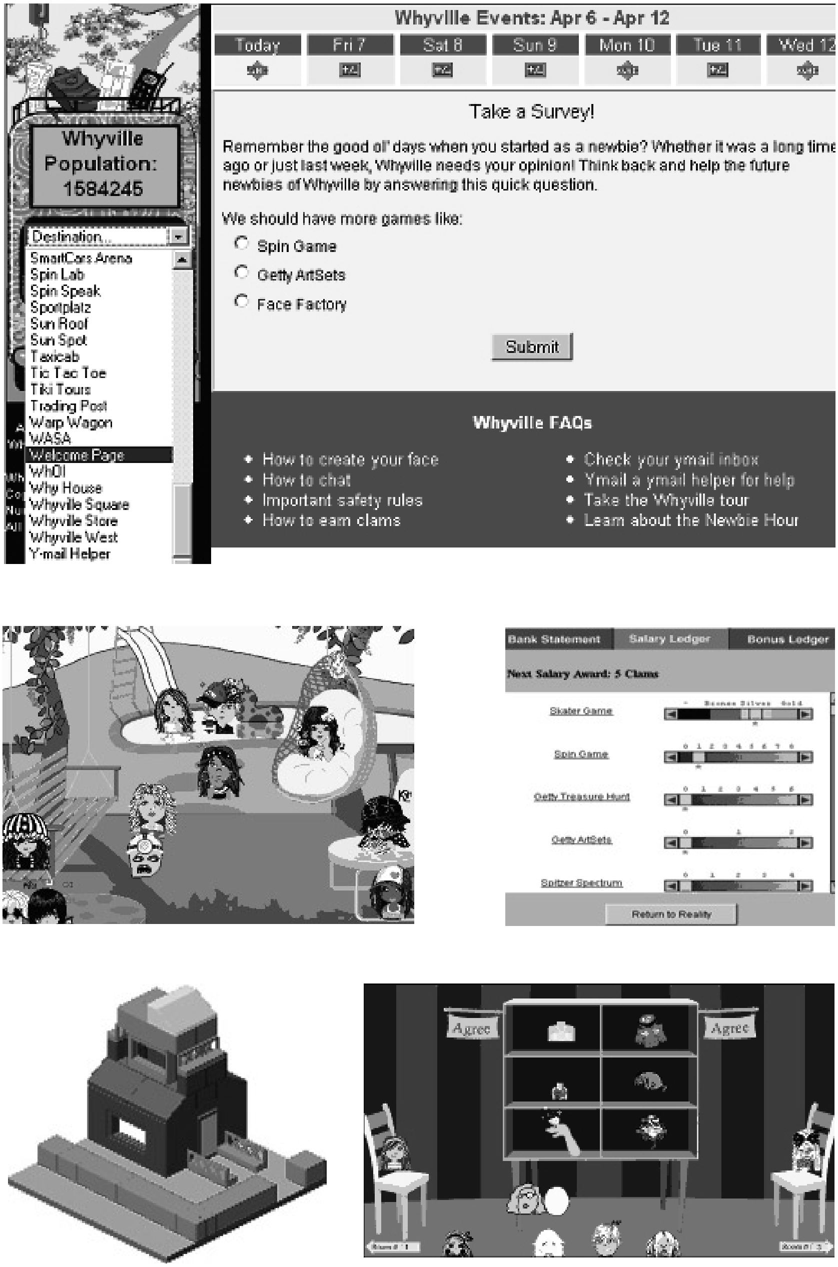


Figure 8.1. Gallery of different Whyville screen shots (clockwise): Welcome screen, Budget ledger, Trading Post, House, and Playground.

Figure 8.2. Screen shot of chatting on the beach in Whyville.

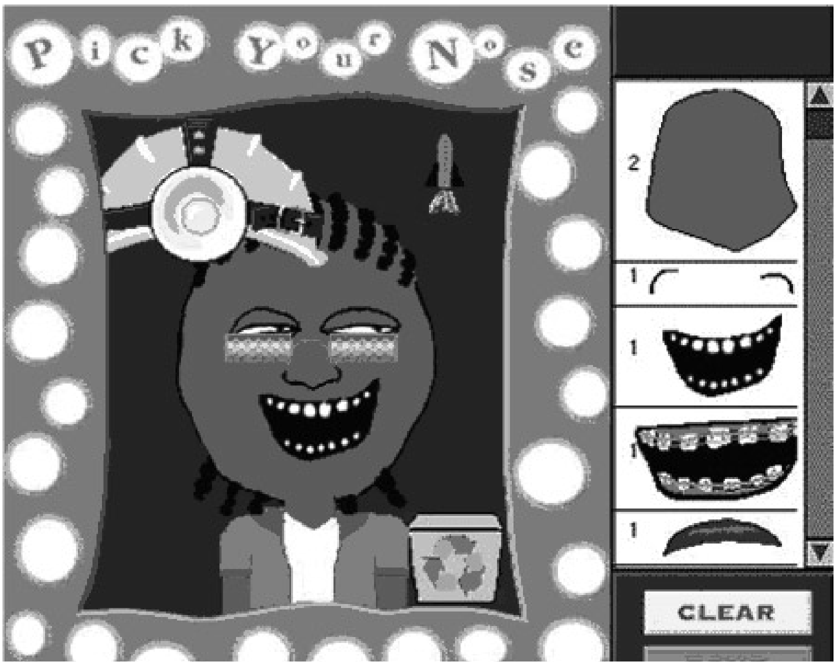


Figure 8.3. Avatar design: picking your nose in Whyville.

Of particular interest to our study are the different types/categories of science games in Whyville, wherein the success at each equates to increases in players' clam salary. At the individual level, most science activities on the site are casual science games. These are one-player games that provide Whyvillians the opportunity to explore different science concepts in the context of a playful activity, or task, with increasing difficulty. For instance, one popular example is the Hot Air Balloon race. In this game, Whyvillians have to navigate a hot air balloon, drop a bean bag over a target on the ground, and safely land the balloon by keeping in mind the burning fuel and releasing hot air (i.e., relationship between temperature and density of gas), speed and wind vectors (i.e., directional forces), and the balloon's position on a coordinate graph. Other casual science games include those from the Spin Lab. Here a player manipulates the position of a skater's arms and legs to make the skater spin as fast as possible, or they manipulate the position and center of rotation of a variety of objects to make each spin faster, thus learning about momentum, rotational velocity, and inertia. Further games include the GeoDig sites where players can learn about different rocks and their origins, and the Rocket Design sites where Whyvillians can learn about velocity, acceleration, and graphing. For all the science games, repeated success at greater difficulty levels equates to an increase in clam salary that is issued at every login to Whyville. See Figure 8.4 for some illustrations of casual science games.

The second category is collaborative science games which have Whyville players sign up in teams to work together on solving a problem. For instance, the Solstice Safari has a group of users working together to collect data about the sunrise and sunset at different locations around the world. This encourages collaboration and social interactions among Whyvillians and teaches them about the earth's position in relations to the sun, notions about time (days, years) and seasons, temperature, and geography (latitude and longitude). A related collaborative game activity is the Sun Spot Alien Rescue in which Whyvillians identify a particular city and its latitude and longitude when given some combinations of clues about an alien's whereabouts (including date, time of sunrise and sunset or number of daylight hours, and geographic information). Players can then use a simulation tool, called the sun tracker, to test visually their solution by representing the path of the sun during daylight, relative to the horizon, for the chosen location and date (Aschbacher, 2003). Other collaborative science games also incorporate casual game components. For instance, in the Smart Cars racing game, Whyvillians design a path of light to navigate their light-sensitive (left and right tires) car to the finish line, and compete with another user who also designs their unique path. The underlying concepts behind this game include the transfer of energy, energy source intensity, and light and

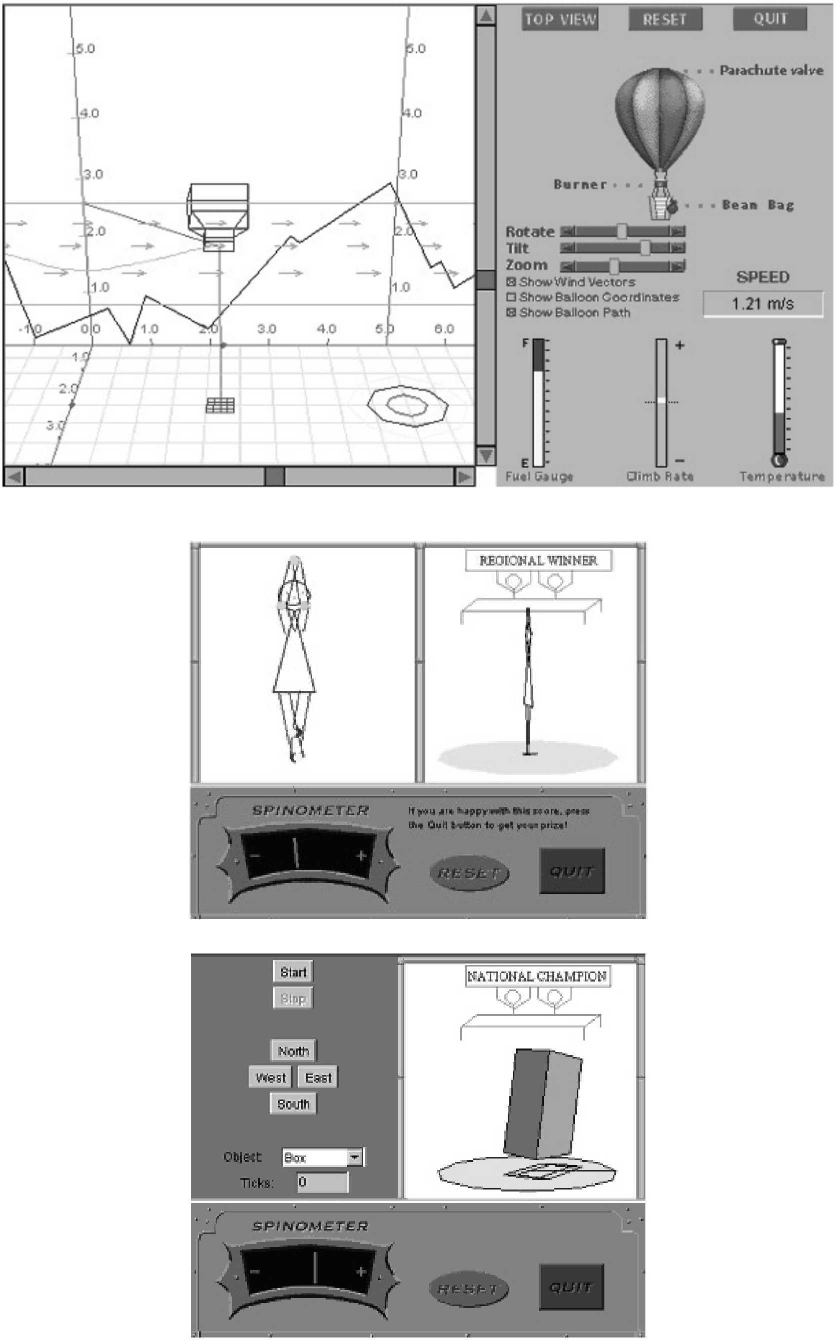


Figure 8.4. Casual science games: Hot Air Balloon game and Spin Lab.

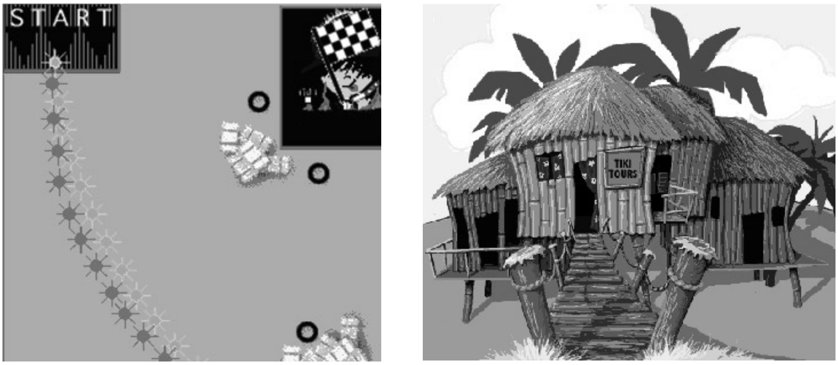


Figure 8.5. Collaborative science games: Smart Cars and the Solstice Safari sign-up locale (Tiki Tours).

mechanical motion. Figure 8.5 illustrates two examples of collaborative science games.

Community science games are the third and perhaps the most unusual category. The most prominent example is the experience of a virtual infectious disease called Whypox that affects the whole community once a year. During an outbreak of Whypox, infected Whyvillians show two symptoms: red pimples appear on their avatars and the ability to chat is interrupted by sneezing (i.e., words are replaced by "achoo"). Whyvillians can become infected in multiple ways—by being close to infected members in the same space, by chatting with others, by throwing projectiles—depending on how the designers of Whyville choose to set the parameters. Unlike adult MUVEs, players' avatars in Whyville do not die or loose power; rather, features central to their community interactions such as chatting and looks are impacted or constrained for a limited time. This approach allows users to draw parallels to real infectious diseases in terms of its spread, symptoms, duration, and cures. Whyville then provides multiple ways for Whyvillians to learn about Whypox and infectious disease (see Figure 8.6). At the individual level, users can learn about Whypox at Whyville's Center for Disease Control (CDC). At the CDC, users can read about past cases, predictions about future outbreaks, and inquiry into cures; they can use tools to simulate the spread of the disease. Contributing to the community and as a source for clam salary, Whyvillians can also write articles about Whypox and post predictions at the CDC based on their readings and the interactions with infected and non-infected others.

When all is well in Whyville, a typical day sees about 14,000 users login for visits that last anywhere from five minutes to more than five hours (average

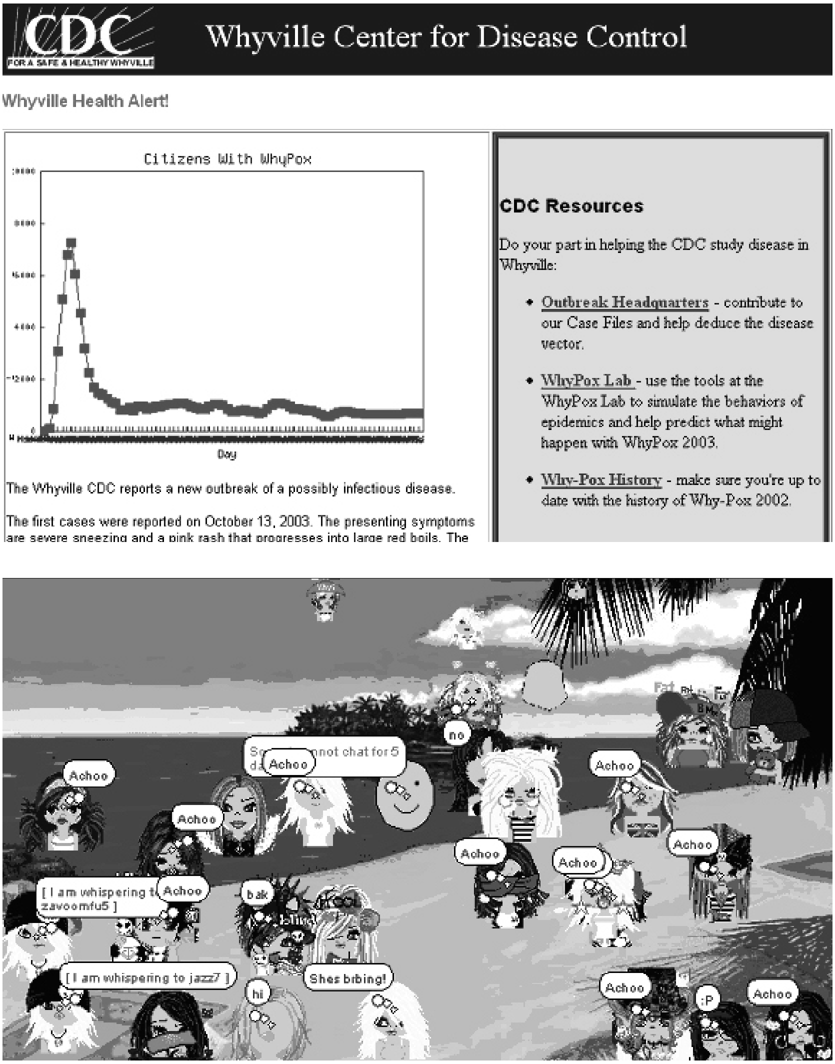


Figure 8.6. Community science games: Whypox graph in CDC and Beach with Whypox infected players.

login length is over 40 minutes) and players participate in over 10,000 science activities on a regular day. We know from a previous study that over 68% of the visitors are girls with an average age of 12.3 years that have computers at home and are interested in science and computers (Aschbacher, 2003; Kafai, in press). In our study, we were particularly interested in students' participation in the various science game activities and the possible integration of these types of science games in the traditional science classroom curriculum.

Playing and Learning with Science Games

In fall 2003, we conducted a ten-week study within a laboratory school where Whyville and Whypox were integrated into the classroom curriculum on infectious diseases. Participants were 46 sixth-grade students (age 10–12) from two classrooms taught by the same teacher. Students signed up for an account on Whyville and participated in Whyville online activities in the classroom and at home. As part of their curriculum, students read about a variety of natural infectious diseases and learned about key concepts by preparing individual research reports about a particular disease. Whyville activities were integrated throughout the class sessions, first by having students login from time to time to acquaint themselves with various aspects of Whyville, by participating in several science games, and by tracking the outbreak in their own classroom community. The teacher organized whole-classroom sessions in which students speculated about the causes and cures for Whypox. Students completed their surveys on Whyville participation and infectious disease understanding at the beginning (Time 1), middle (Time 2), and end (Time 3) of the study.

Playing in Whyville

To assess their actions in Whyville, students completed survey items that asked about their general participation and degree of involvement with science and non-science activities there (see Table 8.1). For general participation, students were asked about their frequency for visiting Whyville (1 = less than once a week, 5 = more than once a day) and salary status (1 = 0–25 clams to 5 = 101+ clams) across three time points. Compared to the beginning of the study ($M = 3.37$), repeated measures analysis of variance across time results showed that students logged onto Whyville with significantly greater frequency at Time 2 ($M = 3.75$) and Time 3 ($M = 3.83$). In addition, students had a significantly higher salary at Time 2 ($M = 1.52$) and Time 3 ($M = 1.93$) than at the beginning ($M = 1.18$) of the study. Because salary is often earned through participating in science activities, writing articles for Whyville Times, and other activities, these results suggest that students became more active participants in Whyville over time.

Students were also asked about their involvement with general Whyville science and non-science activities. Given a list of general Whyville activities, such as chatting, science activities, and sending ymail, students were asked

Table 8.1. Frequency of participation in Whyville activities.

	Time 1		Time 2		Time 3		Time Main	Contrast F-value	
Items	*M*	*SD*	*M*	*SD*	*M*	*SD*	*Effect F-value*	*T1 v. T2*	*T1 v. T3*
How often do you log onto Whyville?	3.38	(1.13)	3.75	(1.01)	3.83	(1.01)	3.32*	5.87*	4.16*
What is your current salary?	1.18	(0.39)	1.52	(0.85)	1.93	(0.97)	20.85‡	11.06†	31.07‡
Science activities	3.07	(0.91)	3.02	(0.91)	2.84	(0.81)	1.52	0.10	2.66
Reading the Whyville Times	2.00	(1.00)	2.00	(0.98)	1.86	(0.81)	0.79	0.00	0.91
Reading bulletin boards	1.67	(0.97)	1.91	(1.15)	1.65	(0.88)	2.39	3.53	0.04
Signing petitions/participating in polls	1.38	(0.88)	1.82	(1.00)	2.09	(0.98)	8.80‡	7.11*	16.61‡
Chatting	1.39	(0.94)	2.91	(1.20)	3.09	(0.82)	31.86‡	36.91‡	69.71‡
Ymail	1.34	(0.75)	2.31	(1.28)	2.67	(0.82)	24.88‡	23.89‡	70.54‡
Hanging out	2.07	(0.90)	3.16	(0.94)	2.75	(0.82)	24.31‡	59.83‡	17.57‡
Shopping at Akbar's/Picking your nose	2.12	(1.09)	3.10	(0.88)	2.64	(0.77)	16.56‡	46.91‡	6.75*

* $p < .05$, † $p < .01$, ‡ $p < .001$

"When you are on Whyville, how often do you do the following activities?" For each item, students were given four possible responses that were subsequently scored on a four-point scale: rarely (1), once in a while (2), almost every login (3), and every login (4). Table 8.1 displays all the items, corresponding descriptive statistics, and repeated measures analyses of variance results across time.

For general involvement with Whyville activities, our students showed a shift towards the social rather than science activities with time. That is, repeated measures analyses results showed that students did not differ across time in terms of their involvement with general science activities, reading the Whyville Times, nor reading the bulletin boards. However, students indicated that they were significantly more involved with signing petitions or participating in polls on Whyville at Time 2 and Time 3 than earlier in the study. The social activities in Whyville became more prominent with time. That is, using Time 1 as the baseline, students reported significantly greater involvement with chatting, ymail, and hanging out at social places at Time 2 and Time 3. In addition, these students also indicated that "shopping at Akbar's" or "picking your nose" occurred with significantly greater frequency at Time 2 and Time 3 than at Time 1. Because much of Whyville involves communications through personalizable avatars, and personalization occurs at Akbar's and the "picking your nose" site, these last activities can be consider both personal and social motives.

Playing casual and collaborative science games

For science games, students reported their rate of participation only at the beginning (Time 1) and end (Time 3) of the study. For each science game, students indicated whether they "never tried it," "tried it," "done it," or felt like an "expert." To measure science game experience, these responses were subsequently scored on a four-point scale, with higher scores indicating greater experience. Frequencies and means of science game participation are reported in Table 8.2.

Results showed the majority of students at Time 1 responded that they either never tried or tried most of the science games. The high experience rate for the two Spin Lab games (Skater game and Spin game) and Hot Air Balloon race were caused by the teacher's initial classroom activity and discussion of Whyville. At Time 3, results showed that most students indicated that they "tried it," "done it," or felt like an "expert" on almost all of the science games. The one exception was the Solstice Safari game that required coordination from Whyville users and website designers to organize their occurrence. For this reason, experience in it was generally low. To analyze change in science game experience, paired sample t-tests were conducted for each game (see Table 8.3). Results showed that students' rates of experience were significantly higher at Time 2 for most of the science games. The only non-significant time differences were for the Hot Air Balloon and Solstice Safari games.

Table 8.2. Expertise in playing casual science games.

	Time 1 *Frequency (%)*		*Time 3* *Frequency (%)*		*Time 1* *Frequency (%)*		*Time 3* *Frequency (%)*	
	GeoGid				**Spin Lab Skater Game**			
Never tried it	32	(.73)	15	(.33)	2	(.04)	0	(.00)
Tried it	8	(.18)	12	(.27)	11	(.24)	1	(.02)
Done it	4	(.09)	7	(.16)	9	(.20)	11	(.24)
Expert	0	(.00)	11	(.24)	23	(.51)	34	(.74)
	Hot Air Ballooning				**Spin Lab Spin Game**			
Never tried it	1	(.02)	2	(.04)	6	(.13)	5	(.11)
Tried it	14	(.32)	11	(.24)	17	(.38)	9	(.20)
Done it	20	(.45)	19	(.42)	11	(.24)	15	(.33)
Expert	9	(.20)	13	(.29)	11	(.24)	17	(.37)
	House of Illusions				**Treasure Hunt**			
Never tried it	22	(.49)	4	(.09)	33	(.75)	11	(.24)
Tried it	9	(.20)	5	(.11)	6	(.14)	10	(.22)
Done It	5	(.11)	10	(.22)	3	(.07)	7	(.15)
Expert	9	(.20)	27	(.59)	2	(.05)	18	(.39)
	Smart Cars				**WASA Rockets**			
Never tried it	25	(.57)	17	(.37)	26	(.59)	16	(.36)
Tried it	12	(.27)	8	(.17)	12	(.27)	8	(.18)
Done it	6	(.14)	8	(.17)	4	(.09)	9	(.20)
Expert	1	(.02)	13	(.28)	2	(.05)	12	(.27)
	Solstice Safari				**WASA Zero Gravity**			
Never tried it	34	(.76)	33	(.73)	19	(.43)	16	(.36)
Tried it	6	(.13)	6	(.13)	21	(.48)	13	(.29)
Done it	5	(.11)	4	(.09)	4	(.09)	9	(.20)
Expert	0	(.00)	2	(.04)	0	(.00)	7	(.16)

Table 8.3. Differences in participation over time in casual science games.

	Time 1		*Time 3*		
	M	*SD*	*M*	*SD*	*p-value*
GeoGid	1.34	(0.65)	2.30	(1.17)	−5.41‡
Hot Air Ballooning	2.84	(0.78)	2.98	(0.86)	−1.29,
House of Illusions	2.02	(1.20)	3.31	(1.00)	−7.58‡
Smart Cars	1.61	(0.81)	2.34	(1.26)	−4.36‡
Solstice Safari	1.36	(0.69)	1.45	(0.85)	−0.78
Spin Lab Skater Game	3.18	(0.96)	3.73	(0.50)	−3.95‡
Spin Lab Spin Game	2.60	(1.01)	2.98	(1.01)	−2.32*
Treasure Hunt	1.41	(0.82)	2.64	(1.22)	−5.70‡
WASA Rockets	1.58	(0.85)	2.35	(1.23)	−4.29‡
WASA Zero Gravity	1.67	(0.64)	2.14	(1.06)	−3.10†

*$p < .05$, † $p < .01$, ‡ $p < .001$

Playing community science games

The outbreak of Whypox presented an unique opportunity to examine players' participation in a community science game. As part of class activities, students went in teams into the Center for Disease Control's archive to read about past Whypox infections and posted statements about possible explanations. Students also used the simulators to try out different parameter configurations (e.g., number of people infected, days of incubation, run of disease; see Figure 8.7). Students also read about previous Whypox outbreaks pulling articles from the archive of the Whyville Times (see Figure 8.8).

In science classes, students tracked their infection rate on a daily basis and noted the names of those who had been infected by Whypox. Students also checked the population graph in the CDC to compare their class' infection rate with that in the community. The discrepancies in rates gave rise to classroom discussions on why not all students had been infected and what might serve as an explanation for the discrepancies. The excerpts on page 211 illustrate the nature and content of classroom discussions: the first one was taken a few days after the first outbreak, and the other a week later towards the end of the Whypox outbreak.

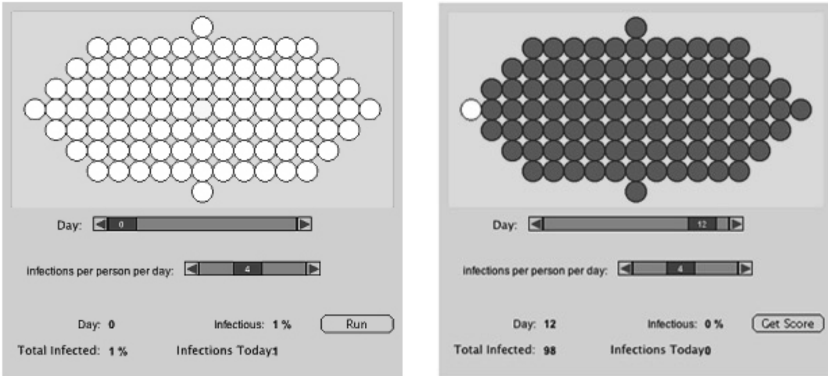
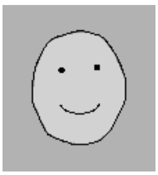


Figure 8.7. Community science games: screen shots of Simulator in CDC.

THE WHYVILLE TIMES

www.whyville.net Feb 28, 2002 Weekly Issue



mewi
Guest Writer

Why-Pox No Good?

Hi, it's mewi here and I want to talk about Why-Pox.

Why-Pox aren't good! I once wanted them, but not any more -- they're infectious and if I get them more people will get them too! So always stay alert and away from people with pox. I'm not saying that you can't talk to your friends on Whyville if they have pox, just stay a fair distance away from them.

Sometimes I wonder, did Whyville's creators just put pox on here for fun or is it a virus or something? Is it on all chat sites or just this one? Who knows??

Also I have heard that if you change your face and also have Why-Pox they will get one step worse until your pox are bright red not just light pink. I have been noticing a large increase of this disease over the past two days. According to my calculations I figure that since in the past few days about 180 people got the virus, it will take about two or three months to reach

10,000 people. So, in a matter of months, almost all Whyvillians will have or have had the pox.
I have taken note of people saying things like you can get pox by someone with pox throwing a projectile at you, sneezing on you, and many other things. Is this real or not? I mean, on Friday I was in the Spin Speak and there were lots of people with pox and I still have none. Does this mean that the pox just comes and goes, or will they never leave your face?

I'm sure everybody knows about the Whyville CDC, so always try to help out by finding information on it and mail it to me so I can try to incorporate a way to get rid of them. Also any information about how to get rid of them or how to get them, mail that to me or Whyville and then we can get it all to stop.

The last thing I want to talk about is a contest I will hold and it will start as soon as this article comes out. I would like to get as much information as possible on whypasses mailed to me so we can get rid of pox. Also another thing that will count as information is how this strange disease got named Why-Pox.

Rules to the contest:
1) Use different information.
2) No cheating; ex: using other people's information.
3) Have fun!
and 4) Have fun!

I will judge the contest by the person who has the most unique information that is true and if a peace of information is on two or more entries it will be

Classroom Discussion at Onset of Whypox Outbreak

Bert: I was at the beach and I went to someone who had them. Then I moved away.

Teacher: So you got them right away? Do you really think you got them from him? If you are around someone who has a cold and I'm around you right now will by after school I have that cold? No. Why? Because it takes a little

Sam: It takes a little time to go through your body.

Teacher: It's called an incubation period. You're not going to get it immediately.

Susan: I got it immediately

Teacher: So, maybe you didn't get it from him. Just a suggestion.

Sam: I wanted to infect other people so. I went close to them and then I went away and then they got it.

Teacher: We're going to have to talk about Whypox ethics. [She points to the graph on the whiteboard and post-its with names of infected students] So the 17th? 18th? Ok we have Anna, Oscar, Al, and Olivia.

Susan: A lot of people in this class have Whypox.

Teacher: We have a lot more in this class. We need to be visiting (*got cut off*)

Sam: Only those people in the other class have it.

Teacher: Interesting difference huh. Saturday? Sunday?

Susan: I have something to say. Well maybe a lot more people have it in here because Tony said that Theo and Sam got it first and since we're usually on the computers at the same time, maybe that we were together and we were at the same room or something.

Teacher: I'm seeing epidemiologists in all of you. You're already thinking about how did this happen, what could be the reasons, you're analyzing it, you're thinking about it. I want you to continue with that line of thought as you're looking at all of the data. Thinking why, how what. Ok, Garth.

Garth: Well you know how people said it was gone a few weeks ago. I think Theo got it first a long time ago then Theo said it's gone. And it said on the news bulletin, Whypox has gone. But then two weeks later suddenly it's like a giant plague

Susan: It's an epidemic.

Garth: It's the giant plague. It traveled back. It's like a Whyplague. Now it's like everybody is getting it.

Susan: It's an epidemic.

Classroom Discussion at End of Whypox Outbreak (a week later)

Teacher: How many of you had symptoms and have just passed. Ok, eight of you have recovered successfully from Whypox. [She is counting raised hands 1, 2, 3, 4, 5, 6, 7, 8]

Sam: I went to beach and only 1 person out of 20 or 30 had Whypox.

Teacher: 1 person out of 20 or 30 and that was different from last week. What was it like? Allen.

Allen: Everyone was sneezing

Susan: Just the opposite. One person didn't and everyone else had it. This time only one person had it and everyone else didn't. So what do you think happened?

Garth: It's passing.

Teacher: So what do you mean passing? Anna?

Anna: All the Whypox is going away.

In a related study (Neulight, Kafai, Kao, Foley, & Galas, 2007), we examined these classroom discussions for science connections and themes that compared the understanding of Whypox to students' understanding of natural diseases. First, when discussing Whypox, students and teachers often related and included natural disease terminology and concepts (e.g., contagious, exposure, symptoms, infection, incubation period, epidemiologist, epidemic, quarantining, immunity). Second, analogies and comparisons between Whypox and real natural diseases (e.g., SARS, plague, common cold) were often concurrently mentioned. Third, students and teachers were shown to provide a combination of experiential, social, and casual references when describing Whypox. That is, they often provided examples of personal experiences with Whypox, noticed someone who has it, and/or present causal explanations or hypothesis about how someone got it.

To investigate the impact of a community science game on science learning, Neulight et al. (2007) analyzed the pre-post data on the impact of Whypox on students' understanding of natural infectious disease (Au & Romeo, 1999). At the beginning and end of the study, students were given a scenario (about a girl whom became sick the day after visiting a sick friend) and were asked the following open-ended questions: "Why did it take a whole day for her to feel sick after the germs got inside her body?" and "How did the germs make her feel sick in so many parts of her body at the same time?" Responses were then coded as either pre-biological (e.g., got sick because they were in the same room) or biological causal mechanism (e.g., got sick because germs grew, reproduced, or attacked cells). Analyses revealed that students generally responded with more pre-biological answers than biological answers to both questions. However, while the number of pre-biological responses was generally similar across time, the number of biological answers increased twofold.

Neulight et al. (2007) also asked students "In which ways was Whypox like a real infectious disease?" and "How do you think Whypox spread through the community?" Responses to both questions drew many parallels between virtual and natural infectious diseases. For the similarities, the majority of responses mentioned that Whypox was contagious, while other responses included the fact that Whypox had symptoms and was analogous to other specific diseases. For explaining Whypox, students mentioned contact, chat, and sneezing; no student was able to generate more functional explanations of how a computer virus such as Whypox would spread in a virtual community.

Discussion

Our investigations into Whyville as a virtual playground revealed that players are drawn to the social activities that constitute community life in Whyville: chatting, whispering, and sending ymail are preferred and prominent activities of Whyville users. Science-related activities, such as the casual games, are completed because they provide other things to do while online and, most importantly, they provide the salary necessary to finance shopping sprees at the local mall for new face parts or resources to trade or purchase new items. The community-driven science games such as Whypox were more successful in drawing Whyvillians into science activities and learning about infectious disease. The classroom discussions about Whypox indicated that the participation in a virtual epidemic allowed students to train their observations and make connections to their understanding of natural disease.

Our analyses of different science games genres provided us with a new perspective on how science could be integrated within an informal MUVE learning environment. The most promising and interesting ones are the community science games because they immerse the whole community in the science experience. The umbrella of community science games can also include casual and collaborative science games that are specifically targeted towards infectious disease aspects. For instance, the simulators in the Center for Disease Control offer Whyvillians the opportunity to run and test parameters for virtual epidemics on a smaller scale. Just running simulations does not make for a rich instructional experience. In a more recent study (Feldon & Gilmore, 2006), we redesigned the simulators in such a way that they provide feedback about the accuracy of players' predictions. Now Whyvillians can continue to run simulations by setting infection parameters but they are also asked to make predictions about the outcomes and to provide justifications. The completed simulations inform players about the accuracy of their predictions and thus provide feedback for parameter changes. We are currently analyzing whether Whyvillians take advantage of these new features to improve their simulation results as a possible indicator for science engagement and learning.

We have also examined other ways to enhance the immersive aspect of the community science game Whypox by tying it more closely to economic interactions prominent in Whyville. We noted that many Whyvillians, including the students in our study, always check their salary ledgers and income when logging in and spend much time at Akbar's buying avatar improvements. The trading post in Whyville is a popular space for finding avatar parts no longer available for sale, for exchanging face parts, or for selling off a not-needed inventory of face parts to generate additional income. We used the recent flu vaccine shortage as an inspiration to create a tighter connection between Whypox and economic interactions (Kafai, 2006). Before an outbreak of the epidemic, one dose of a vaccine against Whypox was distributed to one third of the active Whyville population. All Whyvillians were informed that they needed two additional doses of vaccine to achieve immunity before the outbreak, which they could get via donations or the trading post. As part of our research, we documented baseline data of Whyville's economic activity and the trading volume, interactions, and conversations around vaccine sales and exchanges at the trading post (Kafai, 2006).

The findings from the present study provided us with ample food for thought on what and how to study MUVEs such as Whyville in future studies. It is clear that we need multiple ways to document the complexity of interactions in Whyville—self-reports and observations are a first stepping stone and need to be complemented by automatic data collection tools that track a Whyvillian's pathway through the community. But we also need to investigate Whyville's use in different contexts—classrooms and homes are possible but not the only settings. Many afterschool places are public venues that resemble Internet cafes popular in other parts of the world (Lin, 2005). Afterschool places allow for communal game play when dozens of children are logged into Whyville while being concurrently in a shared physical space of a computer club or community technology center. Kafai (2006) included afterschool programs in different community settings.

Our findings are constrained by some methodological issues. For one, we had to rely on students' self-reports of Whyville use at different time points throughout the project. It is quite possible that students overstated or underestimated their actual participation in Whyville activities. The assessments provided by students thus present at best summaries or compilation of events. Future research will collect behavioral data about students' visits to different places in Whyville and report the time spent on each activity and chatting among participants. Such data would allow us to track students' pathways through the MUVE and establish possible connections between science activities.

We are also aware that the use of Whyville at school and home is not representative of the large number of Whyvillians who join the site on their own leisure time. The inclusion of classrooms allowed us to examine the feasibility of integrating MUVEs in regular instructional science activities. It is not at all obvious how open-ended MUVEs such as Whyville compare to more instruction-driven MUVEs such as *Rivercity*. In *Rivercity*, the occurrence of infectious disease drives students' exploration of the environment but in a different manner: Lab books provide structured activities that direct members to collect data probes at different environmental places to examine the sanitary conditions. *Rivercity* is also a closed environment where students interact with artificial avatars and other class members but no outside visitors. Students who participated in this Whyville study also used *Rivercity* and revealed in comparison that they preferred the social nature of Whyville but felt more focused on science in *Rivercity* (Kao, Galas, & Kafai, 2005).

Conclusions

Our analyses have shown that MUVEs such as *Whyville* offer a promising informal place for children to learn and play with science in multiple ways. The categorization of different science game genres helped us to identify Whypox as a distinct feature of MUVEs because it facilitated the immersion of the whole community rather than individual players. It is clear that these immersive features in MUVEs deserve further design efforts and study in how they can lead to greater engagement in science and technology that possibly might lead to improved understanding of science and technology ideas.

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