the Creative Learning EXCHANGE

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SMALLPOX CRISIS MANAGEMENT SIMULATION

Ron Zaraza, Wilson High School, Portland, OR

Imagine you're called to an emergency meeting. You have no idea why it has been called. When you walk into the room, there are about 20 other people. Half you know, the others are strangers to you. The door is closed. Then the purpose of the meeting is announced. You and the rest of the group have been called together to deal with a major crisis. Because of the experience and special skills of the group, you have been selected to serve as the Crisis Management Team (CMT) for your metropolitan region of about 2.5 million people. There has been a report of a possible case of smallpox from the local University Hospital. The worst-case scenario is an epidemic that could have a death rate of 30% or higher. The CMT's task is to plan and implement a response that will minimize deaths. Every second counts. A delay of even a day could have disastrous results.

This is a frightening scenario and a daunting task. Yet this is exactly the situation that 23 students from three Portland area high schools found themselves in the first weekend of spring break. They accepted an invitation to serve as part of the CMT for an unspecified disaster simulation. They spent 30 hours at Wilson High School, beginning at 9:00 AM on Saturday, March 24, and ending at 3:00 PM on Sunday. In that time they went from the introduction of the problem to a fully developed and model-tested plan for dealing with the outbreak, reducing deaths from a possible 750,000+ to fewer than 250. In the process, they developed a control plan that used the same strategies that the World Health Organization developed over a ten–year period for dealing with smallpox outbreaks.

The disaster simulation evolved out of the Plagues and People activities developed by Jeff Potash and John Heinbokel and initially used by them in their classes at Trinity College in Burlington Vermont. Staff of the CC–STADUS/CC–SUSTAIN projects had a number of conversations with Jeff and John about adapting these materials to high school and middle school. The difficulty level of curriculum materials and the fact that the materials were designed for a semester-long college course mitigated against their easy transfer to the K-12 environment. However, in the last 6 months of the CC–SUSTAIN project, it became obvious that there was some money available for the development of models and curriculum materials that could be used by participants. After lengthy discussions, it was agreed that Jeff and John would attempt to develop a series of modules focusing on the role of smallpox in history. There would be five modules focusing on history and five focusing on biology. The modules were

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System Dynamics and Student Leadership

Dan Barcan, Murdoch Middle School, Chelmsford, MA

Mr. Barcan, shhh." Ryan, a fifth grader at Murdoch Middle School, where I served as the Waters Foundation Mentor for System Dynamics, silenced me as I began to address the students leaving our activity. I explained to him that I was going to tell them not to share their solution with the incoming group, but Ryan was a step ahead of me. "We don't need to," he said. "You can't cheat at this." Then, turning towards the new group entering the room and raising his voice to a level that conveyed calm control without anger or force, he quieted the crowd of teenagers and began explaining the rules to the new group.

Ryan was leading the game as a part of DynamiQue***ST***, an annual meeting for students and teachers from grades five through twelve with an interest in system dynamics. In its first two years it has drawn students from Massachusetts, Vermont, and Ottawa, Canada, who come to display and explain posters showing their insights from work with models, causal loops, and behavior-over-time graphs. Professionals who use system dynamics in their daily work—writers and publishers, consultants, professors—provide expert coaching on each project and then support the students as they apply SD tools to a new problem which is presented to the students that day.

***Leadership** continued on page 10*

A new book from Diana Fisher, winner of the Presidential Award for Teaching Excellence in Mathematics and Science

High School mathematics is tough sledding for many. The difficulty is that most students fail to appreciate that mathematics is "just a language." It happens to be a very rigorous language, one with very little ambiguity associated with its symbols. It's also a very abstract one. And it's primarily the latter attribute, abstractness, which causes many students to falter. Diana Fisher's ***Lessons in High School Mathematics: A Dynamic Approach*** is going to help a lot of these students. Diana's book offers loads of problems that students will find both interesting and fun. She then makes use of the STELLA software's icon-based, non-abstract language to structure these problems in ways that students can easily visualize. Students then can make use of the software's simulation capabilities to explore solutions to the problems. Diana's years of teaching have helped to ensure that her lessons are right-out-of-the-box-ready for you to use in your classroom today.

The book will be available in mid-October. The cost of the book will be $99.00. This includes:

- A teacher's guide
- Student lessons (with unlimited copying rights)
- A CD containing models associated with the teacher's guide
- A run-time version of the STELLA software

The book is available from High Performance Systems. The URL on the HPS website for Diana's book is <http://www.hps-inc.com/education/HSMath.htm>.

EDITORIAL

In view of the events of September 11, the two articles in this newsletter are particularly appropriate. Each article discusses students using the skill set of system dynamics to deal with issues: one in the world of school, as they know it, and one in a simulated disaster. This month that simulation almost comes too close to home. Yet, it only points up that all students should have experiences like those described in Portland, Oregon and Chelmsford, Massachusetts.

It is our job, joy, and duty to prepare our students for the world in which they will live. System dynamics helps to give them the tools, emotionally and intellectually, to cope with the multitude of forces in the world today. When hate and fear lurk around the corner—not only in others, but in ourselves and our neighbors—tools to communicate our mental models, to help understand others, and to help us see the consequences of our actions on the systems in which we live become invaluable.

For one take on our world situation, from the point of view of Barry Richmond, go to the HPS website <http://www.hps-inc.com/Terrorism_Story_Download.asp> At the very least, it will make you think. It is time for all of us to sit back and reflect on what we know about the escalation archetype. It is now up to us to not allow hate and fear to continue to create more and more hate and fear in the world.

On a brighter note, please write down of the dates of the up-coming Systems Thinking and Dynamic Modeling Conference for K-12, which will be held June 29-July 1, 2002. We are returning to the New England Conference Center in Durham, New Hampshire, with their lovely sylvan setting, comfortable accommodations, and wonderful food. We hope you will join us for a learning experience that, if other conferences are indications, will both stretch and enrich you. We are lucky enough to have both Peter Senge and Barry Richmond as our Keynote speakers and are expecting other contributors such as Jay Forrester, George Richardson, and John Sterman to join us there. We look forward to seeing old friends and putting faces with names of those we haven't yet met.

Good luck to you all as the school year gets rolling with the joys and challenges of newness and repetition.

Take care.

Lees Stuntz <stuntzln@clexchange.org>

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to be composed of multiple 1-3 day lessons that could be used individually without using other lessons. Thus, teachers would be provided with a number of "plug-ins" that fit into existing curricula.

Over a three-month period, the first drafts of these materials were developed. They were presented to a group of about thirty CC–SUSTAIN participants and staff in a two–day workshop in January 2001. The presentation took the form of a serious of activities based around a hypothetical bio-terrorist attack using smallpox. Each of the activities was excerpted from the newly developed materials. The teacher response was overwhelmingly positive.

This initial presentation of the materials made it obvious that a similar, but more lengthy and intense, use of the materials in a simulation with students would have great potential as a learning experience and as an exercise illustrating what could be done with systems-based materials. After discussion among the leadership group of the CC–SUSTAIN project, it was decided to attempt a 30 hour long simulation at the beginning of spring break, roughly six weeks away.

The disaster simulation was intended as an experiment to see how useful the materials would be when used with actual students. It was also intended as a first attempt to use systems tools as a centerpiece for a simulation exercise similar to Model UN or Harvard Model Congress. Students were recruited from the three high schools in Portland with the longest established System Dynamics programs: Franklin, Wilson, and La Salle. Twenty-three students signed up, each paying $20.00 to cover food and drink.

The participants had a wide range of experience with systems, ranging from two years of formal modeling instruction—plus an additional two years of independent study work in advanced modeling—to students who had no formal experience modeling, but had taken courses in which models had been used to explore problems and test policies. This mix of skills and experience gave the group a broader skill-set and perspective than focusing on just modelers would have. Five students came from La Salle, six from Franklin, and twelve from Wilson, the host school.

The simulation began at 9:00 AM Saturday, March 24th. As students came in to Wilson, four students were greeted with the news that they had been selected as the leadership group. Once the simulation got underway, they would be responsible for managing it. One member of the leadership group was from Franklin, one from La Salle, and two from Wilson. They were chosen for the particular skills that would be helpful in managing the CMT. One was an exceptionally strong modeler. Another was, in essence, a policy "wonk" who had played the role of a member of the Joint Chiefs of Staff (Marine Corps Commandant) in the Harvard Model Congress. Another had some modeling experience, but had taken two classes in which dynamic models were used to explore problems and policies. She was the expert in using, rather than building, models. The fourth member of the group had substantial modeling experience and expertise, but also significant skill at using models to explore problems. He was the swing person who could communicate well with both modelers and policy-focused people.

Five teachers were involved in planning and executing the simulation: Ron Zaraza, Scott Guthrie, Barbara Culpepper, and Diana Fisher of Wilson High School, and Tim Joy of La Salle High School. Although they introduced some topics and led some debriefing in the early stages of the simulation, they played no role in the actual model building or policy development. Their primary function was as observers.

The simulation began with the introductions and the formation of four–person working groups. These groups could have no more than 2 participants from a single school. Once these groups were formed, the basic "problem" was presented. Participants were given a press release:

UNCONFIRMED CASE OF SMALLPOX IN PORTLAND
By William R. Johnson
©The Associated Press

PORTLAND, Ore. ––An unconfirmed case of smallpox has been reported in a Portland hospital. While the disease was officially eradicated by the World Health Organization in the late 1970s, cases of the active virus are known to exist in U.S. and Russian medical laboratories. These have long been targeted by terrorist organizations. Hospital officials refuse to comment on the situation at this time…

The students immediately began to ask questions about the possible victim, where she was hospitalized, and what was known about the disease. They were, of course, given no further information. They were, however, presented with a next step. The problem they were given was to plan a response for the Portland metropolitan area that would minimize the loss of life. To begin developing this plan, it would be necessary to consider four questions:

1) What do we know at this moment in time?
2) What should we be thinking about as we look to the future?
3) What information do we need to improve our ability to understand the future?
4) Where in the system could and should we be focusing to leverage the system and guide it to some desired set of outcomes?

Each group was asked to spend a half hour thinking about and responding to these four questions. The groups then shared their ideas in a debriefing run by two of the teachers. This set the stage for beginning the research necessary to attack the problem of dealing with a potential outbreak of smallpox in Portland. Due to the "problems of doctor/patent privilege, the confusion in defining ar-

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eas of authority, and the establishment of communications between involved groups", there was no official information in response to question 1 other than the press release. The other questions suggested a number of lines of research and information gathering.

At this point it was assumed that the groups would begin to research the identified questions using Internet resources. The leadership group decided to take control at this point and modify the plan. They assigned areas of research to each group, using the questions developed during the debriefing as a starting point. In their assignments they made certain there was some overlap, but kept it to a minimum to make the work more time-efficient. Built into their assignments was an intermediate report phase. After slightly less than two hours of work, each group met with the leadership group to share progress and receive new direction. The leadership group also developed a chart on which groups listed key discoveries and questions that emerged.

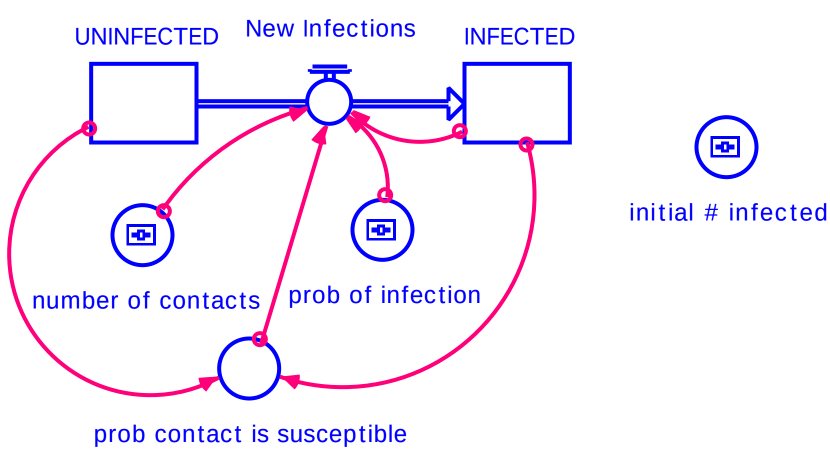
After four hours of work, the large group reconvened to discuss findings. A great deal of information on past epidemics and treatments was uncovered and some key questions were answered. Smallpox could be spread by direct contact or inhaling the virus. Once infected, the disease shows no symptoms for the first 10-14 days. At that point, rash, skin eruptions, and a temperature appear. The victim is only contagious upon the appearance of these symptoms. Within the next week the victim either recovers, developing immunity, or dies. Unlike many diseases, the vaccine, if administered in the first 72 hours, is usually effective in treating the disease, although administration of the vaccine more than 24-48 hours but less than 72 hours after infection may result in a "low-grade" case of smallpox that was very rarely fatal. One of the most surprising pieces of information was that quarantine was regarded as an ineffective strategy for dealing with the disease. This information came from a variety of sources.

When this information was presented, discussions and further questions began to pour out of the students. Several presented plans or parts of plans for dealing with a potential outbreak. The first hard information on the potential victim was released to the group. She was a 34 year-old woman who worked in a day care facility in a blue-collar neighborhood in Southeast Portland. She was admitted very early Saturday morning after experiencing gradually increasing symptoms on Friday while at work. She was married and had two children. No information was available about the health of her husband or children. This information gave a greater sense of urgency to the participants. It was the cue to begin the "education" segment of the simulation.

Most of the participants had not had previous exposure (no pun intended) to disease or infection models. To equip them with basic understanding of how disease spreads, the participants played the Epidemic Game (also known as the Nerd Game, developed by Will Glass–Husain). This activity was debriefed in the large group. The students then were sent back to the computers to build a simple STELLA model of disease transmission, with a goal of understanding what were the key factors that affected the transmission of disease. For those groups that had difficulty developing a model, a simple epidemic model was available. After working with the models, the large group re–formed and debriefed. All of their work developed the idea that critical factors in the spread of disease were probability of infection with a single contact, the number of contacts per day, and the probability of a single contact being with a susceptible person. This led to a larger discussion about how this model would have to be modified to fit smallpox.

All student models, as well as the model we provided, were greatly simplified, with only two stocks: Uninfected and Infected. Obviously, a model for smallpox would have to include the incubation period, a period when a person was symptomatic and contagious, and an outcome, either death or immunity. The students went back to work in their groups to develop this model. Once again, if they had difficulty, they had a pre-built model available. Student and pre-built models all used conventional stocks. This was something of a surprise. We had anticipated that at least a few models would use conveyors. After spending about an hour with smallpox models there was another debriefing session. Some of the student models, as well as the pre-built model, had long run-times. Discussion of the actual situation they were dealing with led to a consensus that the period of

The basic infection model



concern would be a matter of weeks and months rather than years. The participants did feel that they were beginning to develop a real understanding of the problem and could begin to develop a response plan. In fact, they were eager to begin that work.

During the period that students were building and running these two models, they began to have to deal with the "media." Early on, the leadership group realized that public panic could be a major problem. However, they also realized that it would be next to impossible to keep their activities and the potential epidemic totally secret. One of the participants was recruited to serve as their press officer, responsible for writing press releases with the appropriate mix of facts and reassurance. In the late afternoon, "Diane Sawyer" (Diana Fisher) wrangled a press conference that very nearly resulted in a proclamation that there was a smallpox outbreak. Quick thinking by the press officer and two members of the leadership group steered the briefing in a safe direction. The incident made them more aware that they had to leak some information, but had to be very careful.

About the time of the work with the second model, the leadership group issued secure/secret bulletins to local hospitals alerting them to watch for admissions exhibiting the symptoms of small pox. These messages discussed symptoms, but never used the word smallpox. Shortly after this the leadership group was told that the initial victim's husband had been found unconscious in their house in a neighborhood about 1.5 miles south of Downtown Portland. It had been determined that he worked for Kaiser Permanente, driving tissue samples and transplant organs from hospital to hospital in Portland. This initially produced a frantic reaction. The fear was that through the samples and organs he transported, the infection could have spread throughout the city. However, one of the leadership group quickly pointed out that the materials he was carrying would most certainly be sealed for their own protection and, in spite of his contacts with people throughout the city, he could only have infected those he came in contact with after he developed symptoms, no earlier than the last day or two. Still disturbing was the fact that there was no word about the children.

It was now approaching 8:00 PM. The students were beginning to feel a little more hopeful. They had been working for 11 hours, with short breaks for lunch and dinner (Subway sandwiches and pizza). It was time for them to discover that the problem was potentially worse than they thought. Epidemiologists refer to certain types of disease outbreaks as "Virgin Soil Epidemics." In a population with no prior exposure to the disease, and therefore little or no immunity, the disease can hit much harder. Probability of infection for a single contact can be higher. The disease spreads faster. This may lead to a situation where the ill and infected may outnumber the healthy. As a result, it may be impossible to provide basic care for the ill. Victims of the disease die not of the disease itself, but of dehydration or effects of high fevers. In a disease such as smallpox, this can raise the death rate to as high as 90%. There is substantial historical evidence of such epidemics among the indigenous populations of the Americas.

In their research the students had discovered that smallpox had officially been declared eradicated in 1979. No cases in the "wild" had been reported since 1977. Thus, vaccination against the disease had ceased in many countries, including the United States. It could be generally assumed that any Portland resident under age thirty was probably not vaccinated. This group constituted a population very similar to those in the virgin soil epidemics. Further, those sixty or older had probably not had booster vaccinations, so their level of immunity would also make them a population at greater risk. Thus, probably 50% or more of the Portland population fit the profile of a virgin soil epidemic.

> After debriefing of their smallpox models, the participants were told that the problem was potentially worse than they thought. At this point they had been working for eleven hours. Their response to the new information was a mixture of frustration and confidence.

The participants were told about this situation after debriefing their smallpox models. At this point they had been working for eleven hours. Their response to the new information was a mixture of frustration and confidence. While some felt the problem was simply getting too complex, others thought it could be reasonably easily dealt with by modifying their models. There was, however, an underlying sense of frustration because they still did not know if the patients actually had smallpox.

The students were given two models based on historical virgin soil epidemics and told to "exercise" them, that is, to try various combinations of parameters and see how they affected the spread of smallpox. The goal was to have students see samples of how to build a model that took into account the special circumstances of virgin soil epidemics, as well as exploring leverage points in such a system. For the first time, the students' reactions were mixed. They were tired. Participants who thought of themselves primarily as modelers wanted to get started building their models and stop looking at other people's models. Those

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most interested in policy problems wanted to start developing a plan for dealing with the situation. Nonetheless, most began to work with the models, though with less enthusiasm than before.

While the participants were building and exploring the basic infection, basic smallpox, and virgin soil models, the leadership group was observing and talking to them, collecting ideas and information that would allow a comprehensive plan and model to be developed. While they did not actually build the models, by moving from group to group they developed the most complete "picture" of what could happen.

During the time that the virgin soil models were being run, it was announced that the first case had been confirmed as smallpox. This was the only really unrealistic element in the scenario. Only the Centers For Disease Control have the capability of a definitive identification of smallpox. Such identification would take at least 72 hours, and according to some sources, as much as 10-14 days. For the sake of a rapidly developing simulation a confirmation was issued at this point. In a real situation, at most, the presence of some sort of virulent pox could have been established by this time. This could reasonably be expected to trigger a strong response from authorities.

It was also announced that the police who had found the husband had not worn protective clothing. They and the husband were all quarantined at the same hospital the first case had been confined. The children were found in their rooms, non-symptomatic. They too were quarantined.

Participants at this point were achieving little. Some were still working with the virgin soils models. Others were researching parts of the problem, but talking to no one about what they found. A few just sort of faded out of participation. Frustration and a sense of urgency began growing rapidly. About 10:00 PM, one member of the leadership group simply took over, after discussion with her colleagues about what to do. She got everyone's attention, then announced that the previously formed groups should be disbanded. Participants were to divide themselves into three groups: a modeling group developing both short and longer term models, a policy planning group, and a group which essentially served as a research group for each of the other groups. One member of the leadership group monitored/assisted/directed the work of each group. At this point substantive work on the real problem began.

It was quickly decided that it was most important to administer vaccine to those who definitely had contact with the one confirmed and one assumed case. Identifying these individuals had been initiated earlier in anticipation of the need. Working from estimates of contacts for each, it was quickly determined that the number of contacts was probably under 400. The problem was the availability of the vaccine. Various sources found earlier indicated that somewhere between 6,000,000 and 15,000,000 doses were available nationwide, most in a facility in Pennsylvania. These doses would apparently take some time to be prepared for shipping and use. At best, they could begin arriving in 2-3 days. That would have been too late to treat those already exposed.

The research group went looking for other possible resources. They discovered that active-duty military sent overseas were frequently vaccinated, and bases that were likely sources of units had some vaccine on hand. Fort Lewis, Washington, was one such base, only 120 miles north of Portland. The lone remaining teacher determined that 1500 doses would be available. This number was based on the size of units that had "shipped out" from Ft. Lewis in the last five years. The policy team immediately requested the vaccine. The leadership group and the policy team began outlining how the doses would be delivered and how further spread would be discouraged. Knowing that those who had seen active military service overseas had been vaccinated, and having been given authorization to request any necessary resources from civil authorities, the national guard, and reserve units located in Oregon and southern Washington, the group requested that all vaccinated National Guard troops and reservists be mobilized immediately. They also requested that the airport be closed due to "power failure" in the tower.

Upon arrival of the vaccine in Portland, already vaccinated military doctors and corpsmen would be given vaccine to distribute to those already exposed. This administration would begin between 8:00 and 10:00 AM on Sunday morning. In addition, doctors and nurses on duty in area hospitals would be vaccinated, allowing them to be involved in later distribution of vaccine.

This plan would provide a quick response to those identified as having contact with the two cases. The possibility remained that there might be other cases. It was also possible, even likely, that some of the contacts might be missed. This was when the research group told the policy and leadership group that there was one model that had progressed to the point that it would be useful as a policy-testing tool.

The model builders had progressed more slowly than the policy and research groups. Four different models had been begun. However, only one of the model builders had spent significant time looking at and testing the virgin soil models. From that experience he was able to build a model loosely based on those models, but with significant differences that customized the model for the Portland metropolitan area. By 1:00 AM he had a well defined, functioning model that was the tool the other groups used to test policy. He was able to get a few hours sleep before refining his model in the early morning. By contrast, the other three modeling groups built models with significantly different structures. They also built most of each model without testing it, resulting in extensive trouble-shooting problems. Each of these models ultimately was completed and all models produced similar results. However, the other three groups essentially had at least one person working on each model throughout the night.

The first runs of the initial model looked at how critical the number of doses given per day was in slowing the spread of smallpox. At the same time, the researchers were determining that the maximum number of doses that could be prepared and shipped per day would probably be on the order of 40,000. Once that was put into the model, other considerations were explored. Of significant concern was whether or not 40,000 doses could actually be administered per day. The research group used the yellow pages to determine a rough figure for doctors in the metropolitan area. Assuming that no more than half would be available or willing to work administering vaccines, they determined that a very reasonable rate of 50 inoculations per physician per day would allow the vaccine to be fully distributed each day. After exploring other variables, they returned to the question of contacts per day. The earlier research indicated that quarantine of populations was not regarded as an effective way of containing outbreaks. The model runs, however, told a different story. Reducing the contacts per person, equivalent to a quarantine, could dramatically reduce the spread of the disease.

The earlier research indicated that quarantine of populations was not regarded as an effective way of containing outbreaks. The model runs, however, told a different story. Reducing the contacts per person, equivalent to a quarantine, could dramatically reduce the spread of the disease.

The policy and research groups tried to reconcile the difference between the information they found on the internet and the results of the model. In a relatively short time they concluded that what

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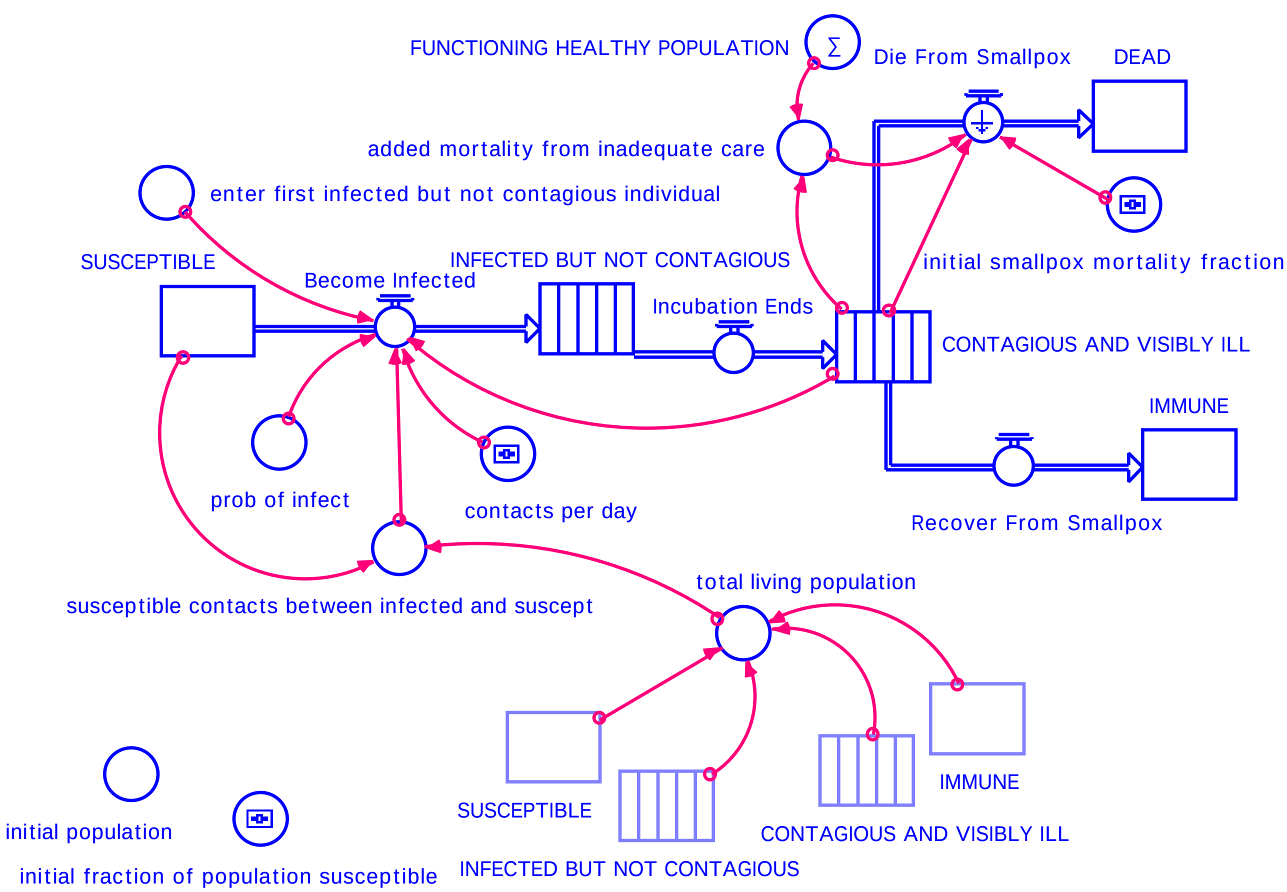
The Aztec Smallpox Model



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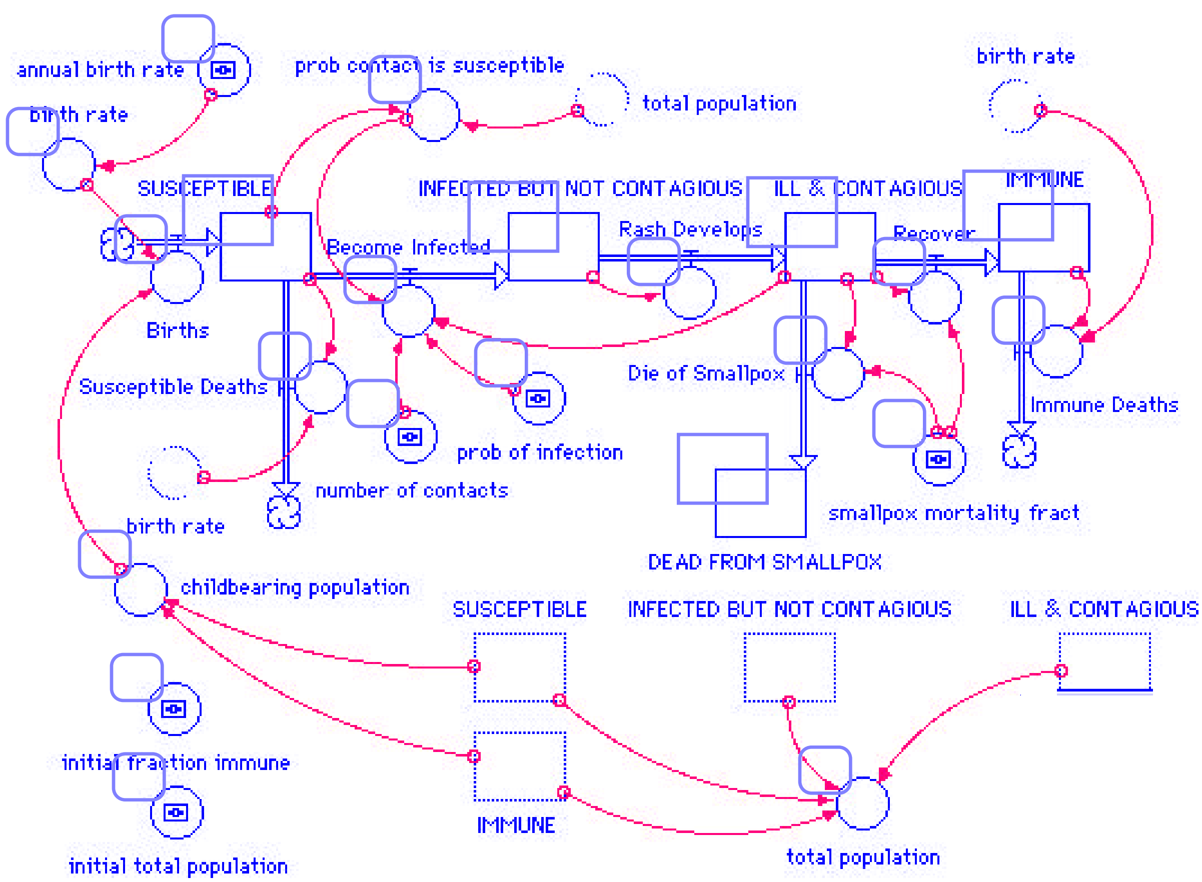
was different about the model and the Portland situation was the very small number of initially infected, the small number of initial "vectors." The more general information referred to epidemics in which the number of infected was larger, and the disease could not be as easily traced to a few individuals. They concluded that the model was correct and that minimizing contacts was as critical, if not more critical, than the vaccine. This moved the policy and research groups into final design of a plan. The modelers continued to refine their models.

It was assumed that large scale availability of vaccine would not be possible until Monday evening or Tuesday morning, as much as 72 hours after the original case presented herself at the hospital. In the forty-eight hours before the inoculations could begin, already inoculated guardsmen and reservists would be used to seal off the major access routes to Portland and Vancouver. This would be accompanied by public announcements explaining what was being done and why. These announcements were to be detailed explanations of the reality of the situation, emphasizing that, unless more cases turned up, there was no way for any others to become ill immediately. As was shown by the infection models, another pulse of infected would not appear for 10-14 days after the first victims showed symptoms. If the rapid response vaccinations (the first 1500 doses) did not reach all the exposed, some new cases might appear at that time.

The possibility did remain that there were others in the population who had the disease but were not yet symptomatic and contagious. Residents were advised to remain in their homes. In the event they ran short of food and other necessities, a system of supply using national guard and army units from Fort Lewis was to be established. To encourage residents to remain at home, all businesses were ordered temporarily closed.

Eighty four inoculation sites were identified around the Portland/ Vancouver area. These were usually schools with gyms and athletic fields or large parking lots, which would allow the vaccine to be administered regardless of the weather. A detailed press released was prepared that explained that the vaccine would be distributed first in the neighborhoods the first cases lived and worked in. The areas would gradually move outward until the entire city was covered. Only those under 30 and those over 60 would be vaccinated. Given that 40,000

The Built Smallpox Model



vaccines would arrive and be administered per day, that meant that between 400,000 and 480,000 people would be vaccinated by the time any new cases derived from the first infected group developed. This would be nearly half of those susceptible. If such cases appeared, the number of new contacts would be minimized by the low number of contacts possible. The vaccine distribution schedule would be revised to focus on the new cases.

In the event that new cases were detected in the first few days of the vaccination program, the quarantine would minimize exposure and the vaccine schedule would also be adjusted. The best-case scenario, no missed cases, all contacts vaccinated, could result in complete control of the outbreak within two weeks. In the worst case, all potential susceptible people would be vaccinated within 6 weeks. Even the revelation, about 10:00 AM Sunday morning, that there were two new cases, both living near the original two, and a press release from bio-terrorists claiming responsibility and threatening further releases of the disease, turned out to be easily handled by the plan. The rest was just ironing out the details and debriefing

The student performance in this simulation was striking for a number of reasons. First is the fact that they stayed in role, in character for the entire time. Although a few "pulled back" from the simulation for short periods of time, even in actual crisis situations response team members need to take time to reduce pressure in order to function. All participants ultimately moved back into the simulation and most never took any real break other than sleeping. In fact, from late Saturday on most became so absorbed into their characters that the level of emotional intensity and involvement was scarcely less than a real crisis would have produced. In several situations, the teacher/observers considered reminding the participants that this was only a simulation. In the debriefing, many said that they lost track of the fact that it was a "game," becoming absorbed and driven by their responsibilities.

Perhaps more astounding is what the students actually accomplished. The solution they developed flew in the face of the "expert knowledge" of the internet reports. In fact, the policy of isolation and large scale vaccination centered on identified cases ("nuking the area", as one student called it) is exactly the policy the World Health Organization evolved over a number of years to deal with smallpox outbreaks. The internet provided many of the basic pieces of information they needed, but their ability to build and use dynamic models allowed them understand the problem in enough detail to plan and test policies for dealing with the outbreak. The models gave them a tool not usually possessed by real-world crisis teams. The models guided their learning about the problem, helped them identify key questions and problems, and allowed them to test their solution. Furthermore, the systems thinking they had learned provided an overall framework for their efforts.

Three of the students presented the simulation at the International System Dynamics Conference in Atlanta in July. Their session was attended by more than 60 people. In it, they talked about the progression of the simulation and their own feelings and thoughts as the simulation developed. They received the only standing ovation of any session at the conference.

This article, with the STELLA models, is available from the CLE and the Web site <clexchange.org>, catalogued under Cross Curricular as CC2001-09SmallpoxCrisis.

News from the Frozen North

Those of you who have had the delightful experience of learning with John Heinbokel and Jeff Potash at Trinity College in Burlington, VT and in their many workshops throughout the country will be interested in their current activities.

When Trinity College closed its doors, Jeff and John worked hard to construct their lives so that they would continue to use system dynamics in K-12 education. They are now affiliated part time with the Vermont Commons School, a middle and high school in Burlington, VT. They have started the year teaching a 9th grade "Human Geography" course (beginning with a systems introduction using Easter Island) and developing a "hunter gatherer" unit for the 7th-8th grade Vermont history course.

Other work on their plate includes working with school administrators to build a model of the relationship between resource allocation and student achievement , doing a workshop in fostering innovation in Muncie, IN, working with the Essex, VT schools, and continuing to work with Will Costello on his initiatives in Williston, VT.

Their new e-mails are:
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System Dynamics and Student Leadership continued from page 1

Developed by Russ Reid, Ryan's Challenge teacher (Challenge is Murdoch Middle School's take on what is traditionally called "gym class,"), the game helps students understand the concepts of feedback and unanticipated consequences by trying to get a team from one end of a room to the other on a "boat" made of a few wooden planks. Most groups find out in a variety of hard ways what happens when part of a team moves before the whole group is ready, or when we try to break systems into small parts and optimize those parts without considering the whole system. All spend about two-thirds of their time trying to "cross the ocean," and the rest debriefing. Though Ryan had his name on the agenda next to the game's title, Russ and I still thought we were the ones in charge. Luckily, we have learned that, when we get a hunch that the kids know more about what's going on in one of these activities than we do, we ought to keep our mouths closed.

It was a good thing we did, too. After we shut up, we got to watch Ryan line up the group on the "boat," spin a story about why they needed to cross the "water," and redirect them whenever they edged towards a violation of the rules in letter or spirit. In one instance, a six-foot tall high school junior asked if his group could take the boat apart, making it into more of a walkway. It was the sort of judgment call that teachers make a thousand times each day. Sometimes we make good decisions and sometimes they return to haunt us, but it takes time to learn how to choose well without agonizing so long that we disrupt a classroom's flow. As I thought of how to answer this student—his idea was a new one—Ryan launched into a poised restating of the rules, explaining that, "even though we say it's a boat, you're really supposed to be learning about your actions and their consequences, so you can decide if that idea would be legal." Keep quiet, I reminded myself.

While I had been spending my year planning with and mentoring Russ and visiting classes each week to observe systems lessons, Ryan had seen his own class internalize some of the lessons we were teaching at DynamiQue***ST*** and knew, he just knew, that he could help other students to learn those lessons as well. From observations at school I had seen him as a polite participant in group activities, but not someone who took over and led other kids. Another student at DynamiQue***ST***, Carisa, acted similarly to Ryan at school. Carisa at DynamiQue***ST***, though, would end the day by challenging the conclusions of one of the coaches—one of the most respected thinkers in the field of system dynamics—in a polite, well-argued group discussion. How many of the adults present would have had the confidence to do that? And, more interestingly, how did these normally reserved students become leaders for a day?

One obvious answer is that most of Ryan's and Carisa's days are not spent using system dynamics. By preparing for DynamiQue***ST***, all these kids had already demonstrated some interest in and acumen for this discipline. Certainly their comfort and expertise with the material encouraged them to take a more active role. But they are "experts" in other subjects at school—writing, math, Capture the Flag—and yet do not demonstrate such tendencies. Perhaps, then, it is *work* with system dynamics, rather than mastery of it, that encourages new leaders to emerge. System dynamics has a variety of qualities that seem to allow different leaders to emerge than those we normally see in the school day:

System dynamics activities de-emphasize competition. When Ryan told me not to worry about students cheating, he had ample evidence for his claim. According to Ryan and Russ, each of the groups they saw that day came up with a different answer. When a group heard about how an earlier group had crossed the ocean, they would consider parts of the solution and integrate or reject them. None saw the challenge as one with a single answer to be found as quickly as possible. Instead, teams strove to solve the problem in divergent, elegant ways. Unfortunately, there are too few opportunities for this sort of challenge in most regular school days, for a variety of reasons. Kids who fear doing something wrong won't step up to lead under those circumstances. But when problems truly do not have a "best answer," these students may feel more confident to lead the way to one of many solutions. Teaching system dynamics encourages divergent thinking and forces us to plan curricular challenges that are open-ended. Less cheating and decreased concern about "getting it right" improve student behavior, which in turn invites new leaders who might shy away from policing their peers.

System dynamics tools appeal to students who tend to find debriefing too abstract. Plenty of activities, from character education to literature groups to science labs, involve some sort of debriefing, in which the class talks to reflect upon the activity just completed. Anyone who has incorporated this valuable tool into a class knows that, while some students benefit from this oral reflection, others tune out or become disruptive during this time. Having students lead activities, including debriefing, can put kids in the tough position of attempting to discipline or make accommodations for their peers. But the tools of system dynamics—loops, models, graphs—provide a visual language within which more students can access what tends to be an entirely spoken activity, with no graphical record. Students who might consider any participation in a debriefing session mystifying—let alone leading that debrief!—may find these tools a point of entry that makes the debrief something they can help others through.

When teachers work as guides, not experts or police officers, different students can see themselves playing our role. When we teach about dividing fractions, or analyzing symbolism in literature, or Manifest Destiny, we usually know more about those subjects than anyone in the room. Even in a student-centered classroom, where kids are led to create their own meaning, teachers still play the role of expert, answering questions and assessing work as needed. Perhaps this role is too intimidating for some kids to take on. But when leading a system dynamics game, we are no longer experts in anything except the rules of the game. Participants ask us questions not because they don't know answers and we do, but as part of a collaborative problem-solving strategy or to help them interpret rules. And no one asks about our assessment, since it is clear to all when a team's process worked and when it did not. For many teachers and students, the latter role is a more natural and fun role to play than the former.

Finally, system dynamics is a low-pressure part of the school day. No one teaches system dynamics because it is on a high-stakes test. It's not a curriculum teachers are forced to "get through." Though some schools or districts may mandate that all teachers learn to use its tools and understand its tenets, it does not lend itself to suddenly appearing in faculty mailboxes in the form of a new book or unit. In addition, most of us would consider ourselves novices at this discipline, and so perhaps it seems more appropriate for a student to lead. As opposed to "core" classes, where we may be more likely to have convinced ourselves—and conveyed to the students—that we know the best way to teach our material, we can be open about the fact that we are all still experimenting with system dynamics. In this environment, we can provide nurturing and un-anxious expectation more readily than we can when we work with the sense that there is little margin for error; and through these expectations we can make it clear that leadership and good, rigorous questioning must be the norm for everyone, not just the teacher or the boldest students. In other words, perhaps these kids lead because we finally let them.

This article is available from the CLE and the Web site <clexchange.org>, catalogued under Systems Education as SE2001-09SDStudentleadrship.

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