Behind Closed Gates: Potential Dynamics When One Individual or Group Is Given Complete Authority Over Another

by Anne LaVigne and Lees Stuntz

Abstract

The Stanford Prison Experiment (SPE), conducted at Stanford University by Philip Zimbardo in 1971, is a powerful example of seeing how people respond in highly stressful situations in which one individual or group has power over another. Although this type of experiment no longer meets the ethical standards for human study, the learning that has resulted impacts current understanding and, in some cases, decisions about how to structure systems, such as penal institutions. Barry Richmond found this and other psychological studies to be perfect issues to consider within the frame of system dynamics. He created models for some of these studies, including the Zimbardo study and the Milgram Experiments. Starting with Barry's original model of the SPE, the model was revised and an interactive interface created, which is now available for use by K-12 educators. Because Barry was willing to share his models with educators, middle and high school students have gained and continue to gain new understanding, connecting these studies to other systems explored within literary and historical contexts. Contained herein is a summary of past model use, the revision process connected to pedagogical needs within a K-12 environment and some initial reflections from a selected group of middle school students and their teacher who used the newly revised edition. The intention is not to report conclusive results, but rather to share a specific example of how an existing system dynamics model was adapted for a K-12 setting.

History

Approximately twenty years ago, a few middle school literature teachers[1] saw a connection between a model that Barry Richmond[2] had created to represent the dynamics of Phillip Zimbardo's Stanford Prison Experiment (SPE) (Zimbardo, Haney, Banks, & Jaffe, 1973) and a book they were studying with their students, *Animal Farm* (Orwell, 1946). The relationships of power found within a prison structure seemed very similar to those that played out within the book. (See Zimbardo's website for additional information[3])

They created a simulation interface for an adaptation of Barry's model that connected relationships among the characters to relationships between prisoners and guards. For a number of years, middle school students in these classes read the book and used the

[1] Orange Grove Middle School, Catalina Foothills School District, Tucson, AZ
[2] Developer of STELLA® software and founder of High Performance Systems
[3] http://www.zimbardo.com/resources/stanford-prison-experiment

simulation to explore relationships and connect them to similar, real-world situations. The teachers have since retired and the students are now all grown. The simulation went out of use and sat dormant for many years.

In 2009, James K. Doyle, Khalid Saeed, and Jeanine Skorinko presented a plenary session at the International Conference of the System Dynamics Society to explore the implications of Barry's model. In their conclusion, they created a challenge for others who might continue this work of connecting psychology with system dynamics: "We also hope Barry's models will gain some use in psychological education. The concept of 'the power of the situation' is contrary to the mental models people form about human behavior through their life experience" (Doyle, Saeed and Skorinko, 2009).

This challenge provided inspiration for finding a way to bring this important work back into the hands of middle and high school students. A goal was to create a context for students to consider their own mental models about individuals or groups with and without power in a variety of situations and to see the similarities among them and, perhaps most importantly, to understand one of the basic characteristics of complex systems as stated by Jay Forrester: The cause of the problem is within the system (Forrester, 2009). For example, students studying *Animal Farm (Orwell, 1946)* often initially conclude that the animals should just have stood up for themselves; perhaps they were just stupid and that's why they did what they did. What they may not initially see is how the circumstances within the situation created the behaviors seen throughout the story.

In an assessment of power and evil, Zimbardo asserts that considering situational influences is vital to understanding human action, in particular behaviors that are considered to be "evil." He also stresses that our understanding of the root causes of these behaviors influence treatment and prevention strategies (Zimbardo, 2005). Having a different context such as this simulation to explore standard units of study can allow students to see and analyze patterns that repeat among a variety of similar situations. In addition, students can start to ask themselves (and use the simulation to test their

assumptions), "Where might the leverage lie if different results are desired? For example, how might one create a peaceful prison structure? How might a group being oppressed by another group free themselves from that situation?

The team at the Creative Learning Exchange began to create a new simulation and curriculum materials[4] for middle and high school students[5]. The main development goals were to:

1. adapt Barry's original model, such that students use slide-bars in a simulation to explore a range of decisions.
2. broaden the context of the simulation beyond one book. The new simulation interface connects prison dynamics to a variety of contexts including literature, e.g., *Animal Farm* (Orwell, 1946), *Hunger Games* (Collins, 1996*), Lord of the Flies* (Golding, 1963), to history, e.g., The Holocaust, and to current or historical revolutions.
3. freely distribute the simulation online along with all accompanying curricular materials for educator use.

Bringing New Life to Barry's Model

The development team consisted of Jennifer Andersen, Anne LaVigne and Lees Stuntz, with feedback provided by Jeff Potash[6]. Jennifer Andersen completed the direct modifications to Barry's model (Figure 1) for a middle school audience in collaboration with other team members. Barry's original model (Doyle, Saeed, and Skorinko, 2009) included only one variable to change, a switch called the "John Wayne" switch. In the actual SPE, one of the participants assigned to play a guard later became known as John Wayne, since his behavior was more aggressive in comparison to the other guards and also seemed to incite a higher level of aggression in other guards as well. A question arose to consider how the results might have been different if that particular guard had not been part of the

[4] Available from http://www.clexchange.org/curriculum/simulations/prison_simulation.asp.

[5] Consent given by Catalina Foothills School District, isee systems, inc., Kathy Richmond and the Waters Foundation

[6] With additional feedback from middle and high schools teachers and support from the Gordon Brown Fund.

experiment. The "John Wayne" switch in the simulation allowed the user to flip the switch in order to remove him, which, in Barry's model, has little impact on the system's behavior (Richmond, 1993).

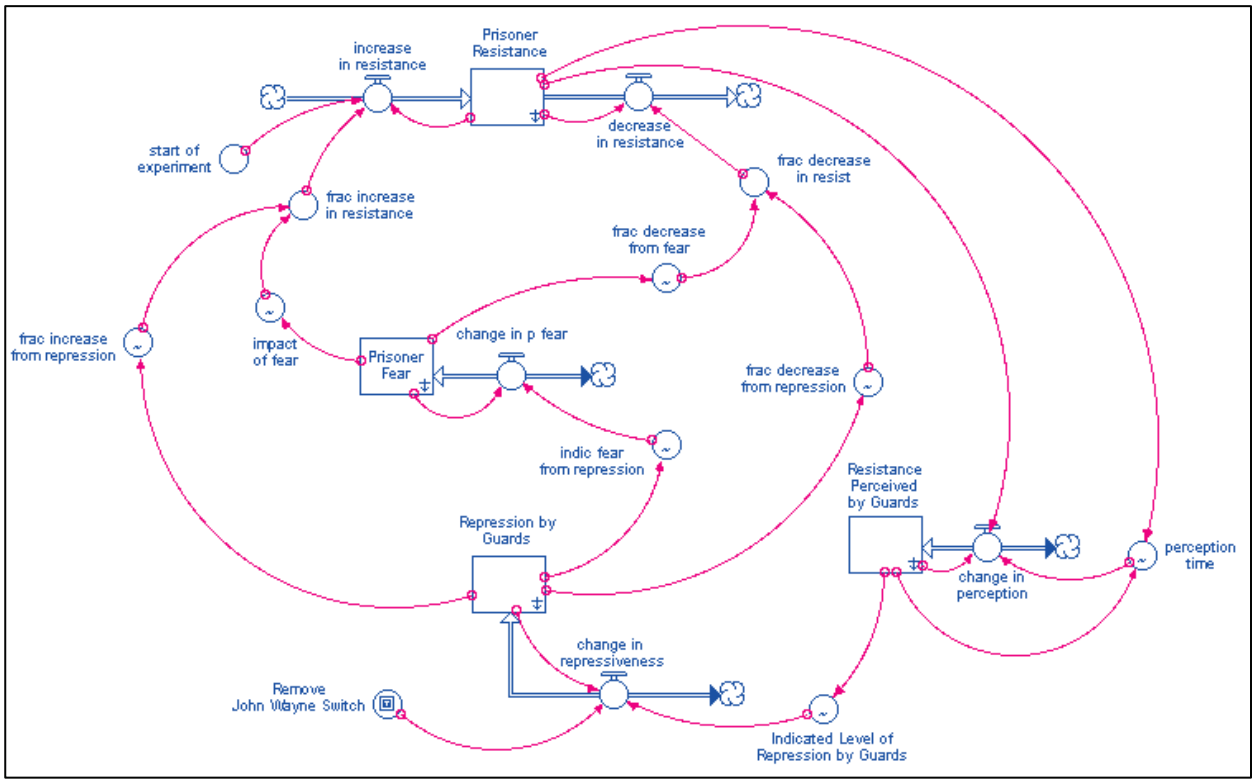


Figure 1: Original Model by Barry Richmond

During the planning stages, the team determined that just having one variable for students to turn on or off was not enough to develop a full curricular unit. The team created a role for students to "play" as they explored the situation. The students would consider themselves social scientists in order to understand what might cause prisoners and guards to behave as they do. The team generated key questions for students to explore while experimenting with the model. These questions centered around the key stocks in the system. The questions were informed by the previous middle school simulation created twenty years prior. These questions included:

- What might happen if the prisoners resisted more or less than they had in the original experiment?
- What might happen if the prisoners were more or less fearful than they had been in the original experiment?

- What might happen if the guards repressed the prisoners at a higher or lower level than they had in the original experiment?

This last question is loosely related to the idea of the "John Wayne" switch, however additional structure was needed in order to create variables that students could push in one direction or the other to explore these and other similar questions.

To modify the model, the team first considered whether any key variables should be added. This determination was based on a consideration of the SPE, Barry's model and the literary/historical connections students could make. The table below shows a comparison between the original and the revised model.

Table 1: Model Comparison

Key Stocks	**Barry's Model**	**Revised Model**
Prisoner fear	X	X
Prisoner resistance	X	X
Prisoner solidarity		X
Guard distrust		X
Perceived resistance by guards	X	
Guard repression	X	X

The team added "Prisoner solidarity" to represent the concept of prisoners working together, an element that also influenced the original experiment. In addition, it plays out in other systems of power, non-fictional and fictional. For example, in *Lord of the Flies* (Golding, 1963) the different gangs of boys either do or don't stick together in their efforts. "Guard distrust" replaced the variable in Barry's model called "Perceived resistance" but focuses on the same basic concept. All other key stocks remained the same (Figure 2).

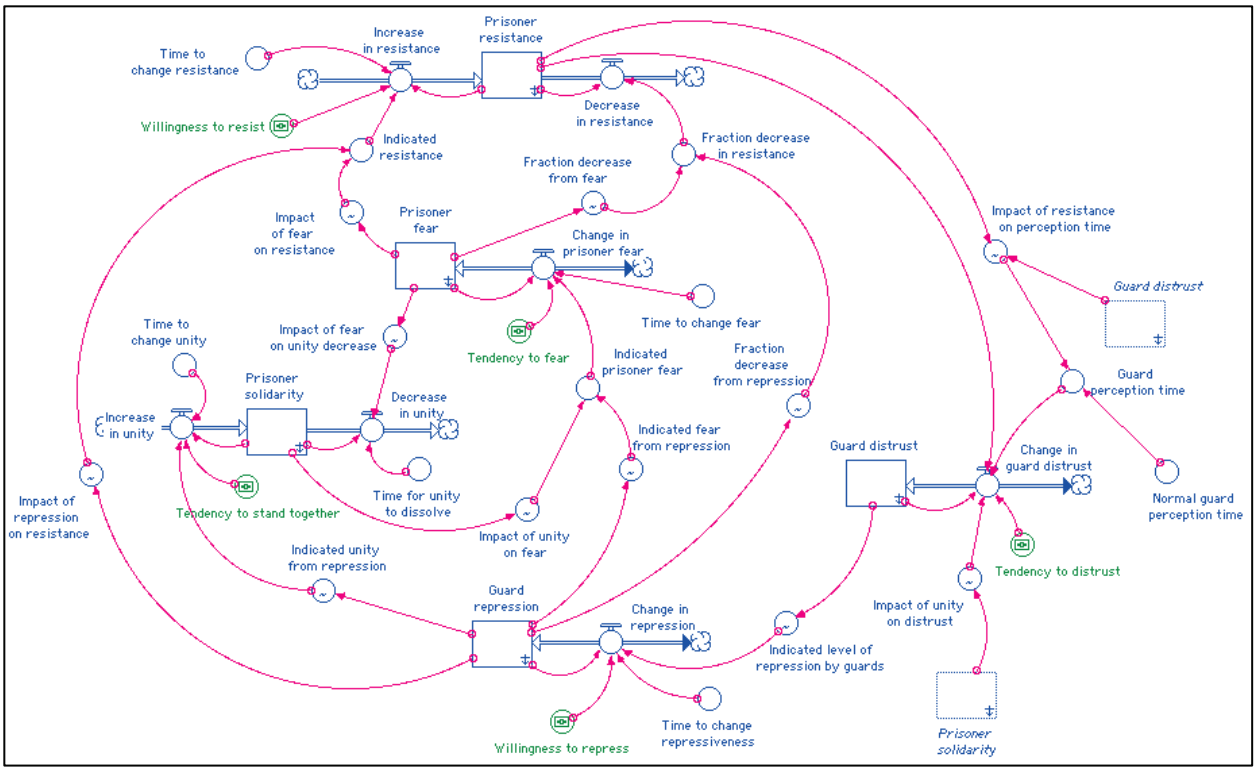


Figure 2: Revised Model

In order for students to change inputs to these key stocks within a simulation context, the team first created indicated levels for increasing or decreasing each of the stocks, which were based on the values of other stocks. The relationship between any given stock and an indicated level is based on the team's perception of what occurred in the original SPE and also aims to remain true to the original structure and behavior produced by Barry's model. The resulting run with no changes to the indicated variables creates a baseline behavior (Figure 4). To make it possible for students to impact these endogeneous variables, multiplier variables shown in green (tied to slide bars on the interface) were added to allow students to increase or decrease a particular willingness or tendency toward behaving in a particular manner. For example, for indicated resistance of prisoners, a willingness multiplier of '1' produces the baseline behavior. If the multiplier is set to a lower willingness to resist (e.g., 0.1) or to a higher willingness to resist (e.g., 2.0), then it affects indicated resistance accordingly. Combining multiplier settings for different variables allows for the exploration of a variety of impacts. Appendix A includes all equations in the revised model.

Once the indicated levels were determined, an interface (Figure 3) was designed. The interface created an interactive environment for students to:

- gather background knowledge about the original experiment and prisons in general,
- consider questions for exploration,
- set new values for the multiplier variables,
- make predictions,
- run simulation tests,
- make comparisons between the baseline behavior, predictions and test runs,
- reflect in a journal throughout the experience,
- access debrief materials, such as seeing the model structure with underlying assumptions, and
- make connections to other similar systems.

The simulation interface[7] is not set up as a predetermined, linear path of experience. Rather, students can view any part of the simulation in any order desired, e.g., view the model, access any of the resource materials, or run the model. For a particular run, students might view the baseline graphs saved in their journal (a word-processing document created through the "Briefing Room"), view the model structure on the "Debriefing" screen, go to the "Control Room" to set up the simulation, visit the "Predictions" screen to draw out their theory, return to the "Control Room" to run the simulation, and access their Journal to reflect on the results. For another run, students might see value in exploring some of the background information in the "Resource Center" beforehand. This flexibility allows for the experience to be self-directed, based on a need to access particular information at a particular time.

[7] http://www.clexchange.org/curriculum/simulations/prison_simulation.asp

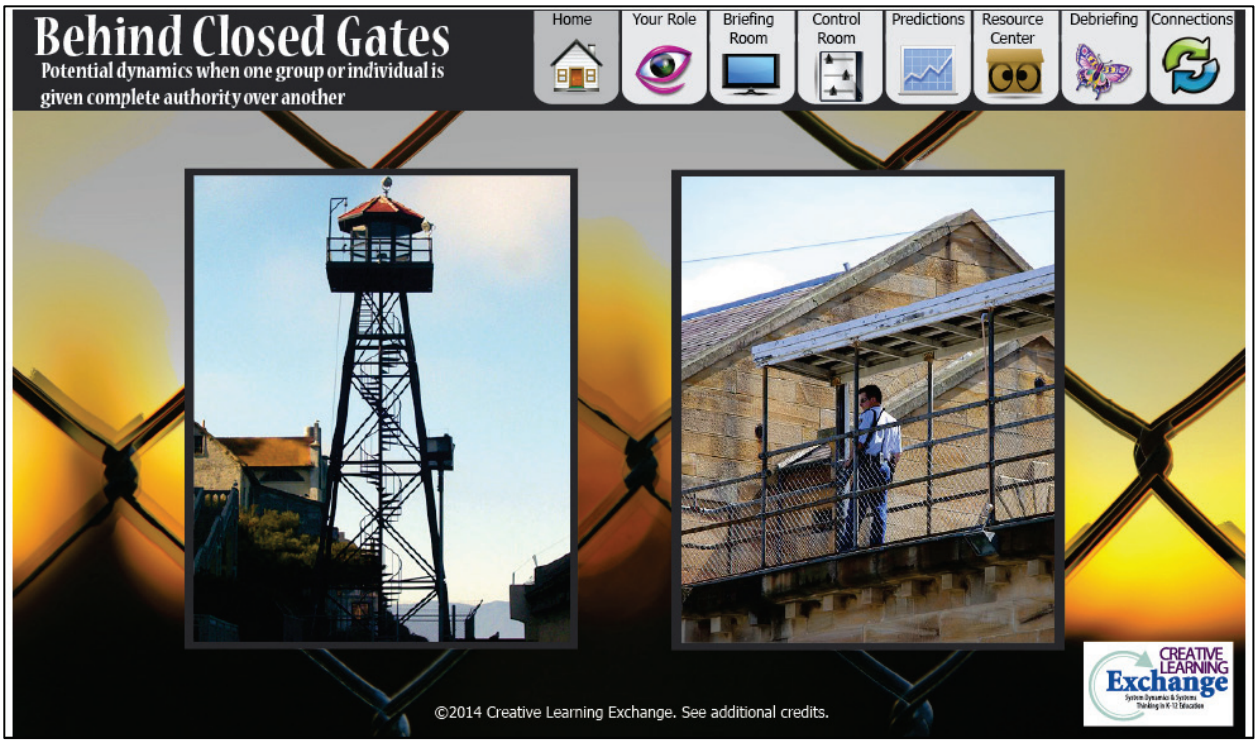


Figure 3: Simulation Interface

The key process for creating a test run is that students set one or more of the multipliers, leaving the levels as they were in the original experiment (as a multiplier of 1) or decreasing or increasing these multipliers, e.g., doubling an indicated value by setting the multiplier to 2. These variables, shown in green in the revised model, are named as a willingness or tendency for guards or prisoners to engage in a particular action or emotion (Figure 2). For example, students can double or halve the guards' willingness to repress the prisoners to see how both the guards (and the prisoners) would behave in comparison to the baseline run. Students make predictions, run the simulation and look at the baseline graphs (Figures 4 and 5) in comparison to the new run in order to determine the overall impact of the change(s).

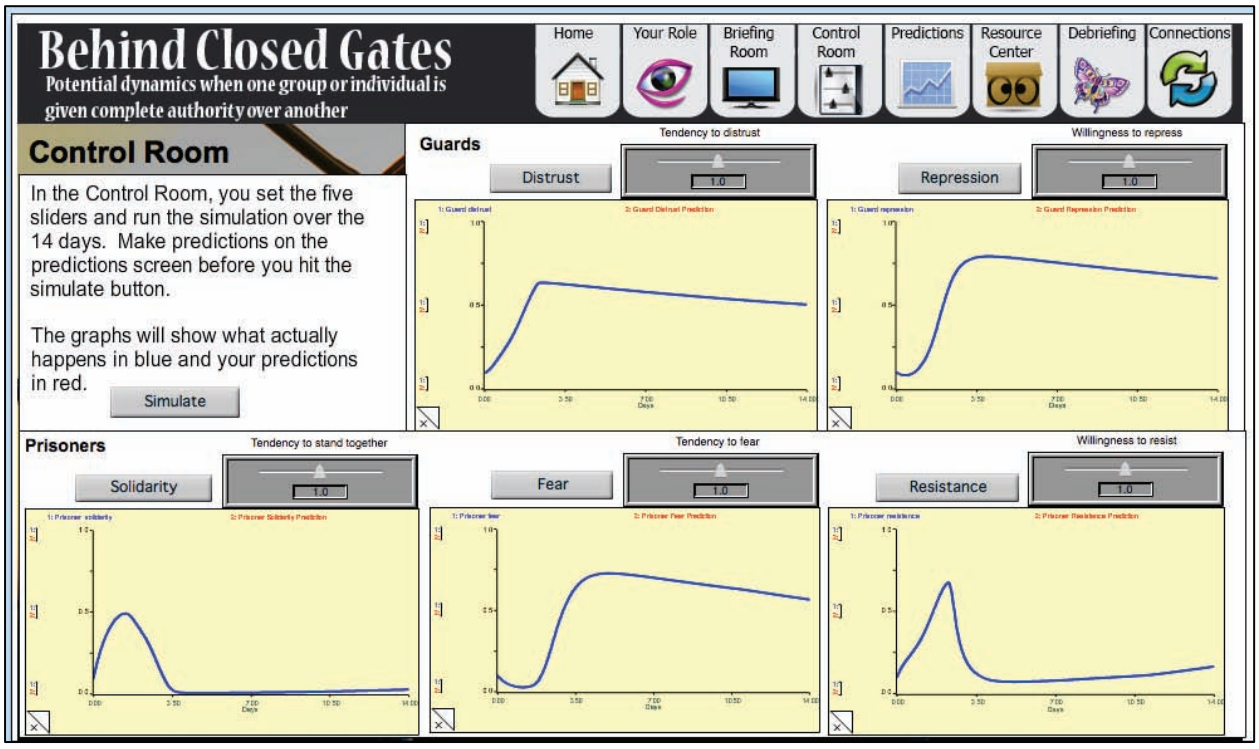


Figure 4: Baseline Graph

The Baseline Graph Story:
In the original experiment by Zimbardo, the prisoners initially tried to unite in solidarity. Their fear level went down, and they resisted the directions of the guards. This caused the guards to increase their level of repression. They did not trust the prisoners. They began to take increasingly hostile and humiliating actions against the prisoners. This caused the fear level to rise and the resistance to be pushed back down.

Figure 5: Baseline Graph Story

They also compare what happened in any particular run to their predictions. These comparisons can help students ask new "What if" questions, explore model interdependencies and make comparisons to other similar systems. See Appendix B for an example student run and response.

It's important to note that the main intent of the simulation is not that students understand the dynamics of prisons, but rather that they are able to make connections to other similar systems they are studying. The connections section (Figure 6) and the accompanying lesson guide provide examples of multiple contexts in which middle and high school students can make comparisons. The original simulation was designed specifically for middle school students reading *Animal Farm*, but many other literary works, such as *Lord of the Flies,* and more recently, *The Hunger Games* series have strong connections to the underlying structure and resulting dynamics.

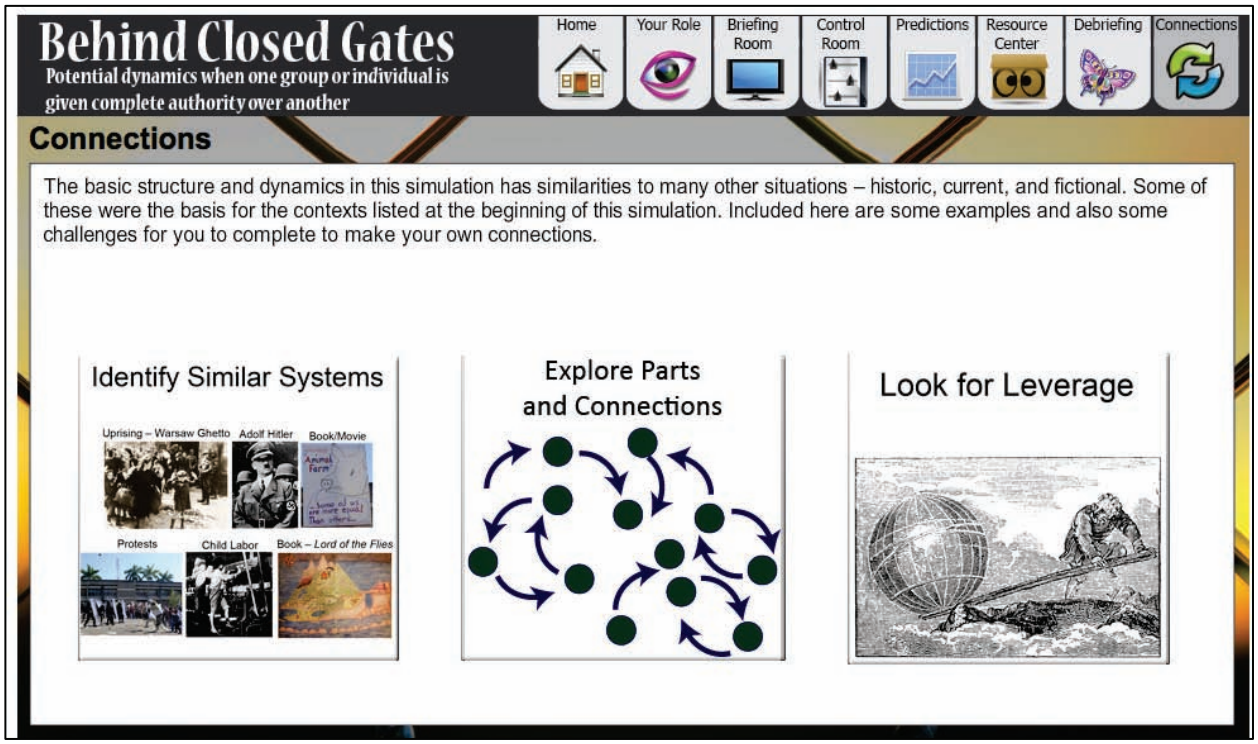


Figure 6: Connections Section

A simplified diagram (Figure 7) with variables renamed for *The Hunger Games* context illustrate an example of how leverage might be perceived from different characters' points of view.

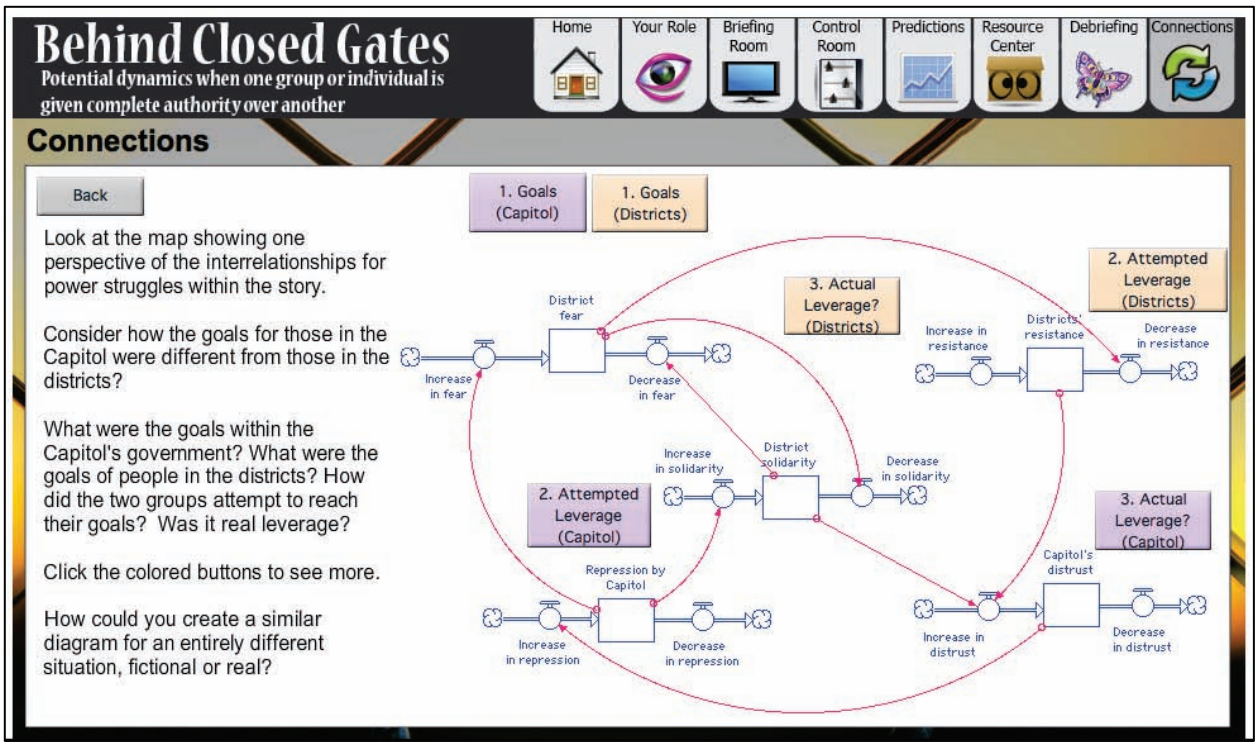


Figure 7: *The Hunger Games* Example

In addition, historic and current realities, such as the Holocaust, child labor, slavery, civil rights, Hitler's Germany, and the Arab Spring strongly relate. Students can make specific connections between the relationships seen in the simulation and those seen in real life contexts, such as:

- Who are the "prisoners" and who are the "guards?"
- How do similar variables come into play in both situations?
- How does fear and/or solidarity affect the ability to resist an oppressor?
- How do those in power maintain control over those not in power?
- How might underlying interdependencies either maintain a status quo or push toward a different result?

Teacher and Student Reflections

During the testing period and final release of the simulation and materials, experiences were gathered from two teachers who have used and continue to use the simulation with their classes, one a middle school language arts setting and the other a high school humanities setting.

Figure 8: Interview with Middle School Students

These teachers report very positive impacts on their students. Students using the simulation are highly engaged, discussing potential scenarios with one another as they decide how to change simulation variables. After each run, they continue to discuss, changing subsequent runs to reflect new learning. Shortly after using the simulation in connection with reading *Lord of the Flies* (Golding, 1963), several students and their teacher were interviewed as a way to have them reflect on the impact on their thinking and learning (Figure 8). Below are excerpts from that interview (Table 2). Note that for the sake of clarity, "kind of," "um," "like" and other similar fillers are not included in the responses.

Table 2: Interview with Middle School Teacher and Four Students

Question	Response Excerpts
What did you learn from doing the Behind Closed Gates Simulation?	• Really cool how these all these elements, like resistance, solidarity of the prisoners, etc., how they're all connected and how they all affect each other. • When you change one, all of them obviously change. It was really interesting to see that circular effect and the effects they have on each other. • I learned that power can ultimately lead to corruption. It was seen in the simulation as the power of the guards increased, their harsh treatment of the prisoners increased simultaneously. • You can see definitely see how certain things affect other things more than other things affect those same things.
How do you think the simulation increased your understanding of the book, *Lord of the Flies* (*LOTF) or Animal Farm (AF),* which we also read?	• The simulation itself was very similar to *Animal Farm* because of the whole, people in charge/people under them and how it started out fair but eventually the power that the guards and in AF, the pigs had lead to them making the lower peoples' lives miserable. • It helped be understand a lot more that AF can be also closer to other things in real life and helped me understand the whole story. • I think the prison/guard simulation was similar to LOTF, because it was seen in both, but as a person was put into a situation of authority, their savagery skyrocketed. Like when Jack was put into a position of authority in LOTF, his savagery increased and that was seen through the brutal murder of some of the pigs on the island and Simon's murder as well. • There [are] a lot of the same factors in both of the stories. You see the same things change in the simulation as well as in the books, so it helps you understand what a character's driving motivations are and what affects how they're doing, so how they think and that helps you understand where the story's going and how it developed. • I also found a big theme in both *LOTF* and the simulation was fear and how it affects the behavior of the different characters, so I already began exploring that with LOTF and how when the boys were afraid, how it [lead] to crazy things. And the simulation reinforced that and allowed me to explore it further.
Why do you think it's a good idea for teachers to use simulations like this one?	• Helps people play around with things and see a lot of different scenarios and toy with what affects what, so everyone can understand what's going on and we can talk to people in the group and get different ideas. • It's so much more powerful to be able to experience and play around with these factors yourself and predict what will happen, because it really gets the creative juices flowing, rather than just reading about it. These can definitely apply to real life – you see corruption and fear all the time in history. • I think these simulations allow one to make easy connections between some of the archetypes seen in stories and the archetypes seen in the simulation. As I said earlier, as someone is put into a

	position of authority, their power skyrockets and we saw that in the simulation through the graphs, and you can take these graphs and expand on them a little bit and put them in terms of the story and that allows for easy connections both between the story and the simulation. • Seeing the patterns of the archetypes also helps us in the future. So, if we can predict what will happen, [e.g.,] if solidarity increases or whatever factor, we can try and prevent some of the bad effects that can come along with that. • Making predictions, being able to do that… even if you're completely wrong, predictions help you understand what's happening and help you boost your understanding of how archetypes work in general and what factors affect different factors, because you're able to think for yourself. • If you get a prediction wrong, it helps you understand, because then you have to understand why you got it wrong, and afterwards you can actually see why. • We tried to get inside of [the heads] of the people who had made the graphs on the program. Why would they think this would happen…. • We also looked at the original [baseline graphs], so we could tell how things affected those things and why we were either right or wrong.
What other comments or questions would you have that you think are worth talking about?	• Since this only happen once…I wonder if different conditions [for the SPE], how it would have changed [the result] today. Those things [in the original experiment] are fixed, but I wonder if it can still be changed? • I think it would have been interesting to see exactly what affected different things. We saw the graphs of the what, but when we had the big overarching structure with the thousands of little arrows, it would have been cool to see what you [meaning the student using the simulation] did, fit in with that model…. • I liked how it showed your prediction on the graph and then it'd show you what actually happened.
At the end of the interview, one student asked the teacher, "Why did you choose to use this simulation?"	…The main thing is it allows you a chance to do an experiment without actually doing an experiment… This is a safe way to let you do that and plus it's so quick. You can make changes very easily and see what's going to happen very quickly, and you don't have to have two weeks to do something that takes two minutes. That's a big thing. I think it connects. Like you said, I think the ideas in it are powerful ones. It's in books, but it's a little bit different when it's in real life. You see this isn't just a story; this is something that we see in real life as well.

Overall, their thoughts show that the simulation was useful in helping students connect what they were studying in class to other real-life situations. They felt more empowered to think for themselves and to draw their own conclusions, based on the self-directed nature

of the simulation experience. Having other students with whom to discuss their ideas fostered an interactive, engaging experience to test ideas in a non-threatening, low-stakes environment. The experiences of the students who have used the simulation thus far and the content of this interview with just a few students is just a small sampling of the potential for learning.

Certainly, additional data will be useful in determining whether these reflections are truly representative of teachers and students in general. However, going back to the beginnings of this work in K-12, we know that students tend to find these types of experiences interesting and empowering. These middle school science teachers who used similar simulations starting more than 25 years ago state, "Students shift from being passive consumers of information that need only be remembered until the next exam, to being active participants in the acquisition and utilization of knowledge. In this environment they become intrinsically motivated to extend the information they have learned" (Draper and Swanson, 1990).

Conclusion

After adapting the model, building a new interface, testing within classrooms in both middle and high school and developing a teacher guide with handouts, this new resource is available for widespread use. Educators can access the simulation and download the free guide from the Creative Learning Exchange (CLE) website: http://www.clexchange.org/curriculum/simulations/prison_simulation.asp.

Because of the highly engaging, interactive, and self-directed nature of simulations such as this one, a challenge is to continue to develop other useful models with accompanying experiences that align with K-12 curricular goals. This challenge would be best met through identifying future partnerships with individuals or groups who could fund such efforts, experienced Systems Dynamics modelers, K-12 teachers and K-12 implementers of systems thinking/dynamic modeling. The team assembled for this project brought together that exact combination of experience.

Barry also created a model (Richmond, 1977) for the Milgram Experiments (Milgram, 1963) that has strong connections to understanding historical events and themes studied in K-12 and would also create an engaging context for students to explore. As one student states in the interview, "It's so much more powerful to be able to experience and play around with these factors yourself and predict what will happen, because it really gets the creative juices flowing, rather than just reading about it. These can definitely apply to real life – you see corruption and fear all the time in history." Now is the time to consider, how can others share their expertise as Barry Richmond chose to do over many years within K-12? How can others like Barry, learn from the experiences and expertise of K-12 educators? How can we together continue to create similar valuable learning experiences for this generation of youth?

Supporting Materials

Behind Closed Gates : CC2014_Behind Closed Gates.pdf

Behind Closed Gates Simulation Model: BCG-modelonly.stmx

The entire Behind Closed Gates curriculum is available online:

http://www.clexchange.org/curriculum/simulations/prison_simulation.asp

Appendix A: Revised Model Equations

{ VERSION 10.0.4 }
{ INITIALIZATION EQUATIONS }
: c Initial_guard_distrust = 0.1
: s Guard_distrust = Initial_guard_distrust
: c Initial_guard_repression = 0.1
: s Guard_repression = Initial_guard_repression
: c Initial_prisoner_fear = 0.1
: s Prisoner_fear = Initial_prisoner_fear
: c Initial_prisoner_resistance = 0.1
: s Prisoner_resistance = Initial_prisoner_resistance
: c Initial_prisoner_solidarity = 0.1
: s Prisoner__solidarity = Initial_prisoner_solidarity
: c Normal_guard__perception_time = 0.25
: c Impact_of_resistance_on_perception_time = GRAPH(Prisoner_resistance / (Guard_distrust + 0.001))
(0.9, 120), (0.92, 120), (0.94, 110.933333333), (0.96, 88), (0.98, 40), (1, 8.55555555556), (1.02, 1), (1.04, 1), (1.06, 1), (1.08, 1), (1.1, 1)
: c Guard__perception_time = Normal_guard__perception_time * Impact_of_resistance_on_perception_time
: c Tendency_to_distrust = 1
: c Impact_of_unity__on_distrust = GRAPH(Prisoner__solidarity)
(0, 0.75), (0.1, 0.761904761905), (0.2, 0.792857142857), (0.3, 0.852380952381), (0.4, 0.969047619048), (0.5, 1.20476190476), (0.6, 1.36428571429), (0.7, 1.42857142857), (0.8, 1.46904761905), (0.9, 1.49047619048), (1, 1.5)
: b Change_in_guard_distrust = (((Prisoner_resistance * Tendency_to_distrust) - Guard_distrust) * Impact_of_unity__on_distrust)/ Guard__perception_time
: c Impact_of_unity__on_fear = GRAPH(Prisoner__solidarity)
(0, 1), (0.1, 0.979), (0.2, 0.958), (0.3, 0.932), (0.4, 0.903), (0.5, 0.866), (0.6, 0.831), (0.7, 0.785), (0.8, 0.76), (0.9, 0.75), (1, 0.75)
: c Indicated_fear__from_repression = GRAPH(Guard_repression)
(0, 0.00952380952381), (0.1, 0.02), (0.2, 0.045), (0.3, 0.089), (0.4, 0.179), (0.5, 0.301), (0.6, 0.459), (0.7, 0.626), (0.8, 0.749), (0.9, 0.863), (1, 0.971428571429)
: c Indicated__prisoner_fear = Indicated_fear__from_repression * Impact_of_unity__on_fear
: c Tendency_to_fear = 1
: c Time_to_change_fear = 0.5
: b Change_in__prisoner_fear = ((Indicated__prisoner_fear * Tendency_to_fear) - Prisoner_fear) / Time_to_change_fear
: c Indicated_level_of_repression_by_guards = GRAPH(Guard_distrust)
(0, 0), (0.1, 0.053), (0.2, 0.122), (0.3, 0.256), (0.4, 0.439), (0.5, 0.65), (0.6, 0.772), (0.7, 0.878), (0.8, 0.939), (0.9, 0.976), (1, 1)
: c Time_to_change__repressiveness = 0.5
: c Willingness_to_repress = 1
: b Change_in__repression = ((Indicated_level_of_repression_by_guards * Willingness_to_repress) - Guard_repression) / Time_to_change__repressiveness
: c Fraction_decrease_from_fear = GRAPH(Prisoner_fear)
(0, 0), (0.1, 0.02), (0.2, 0.065), (0.3, 0.23), (0.4, 0.445), (0.5, 1), (0.6, 1.3275), (0.7, 1.5), (0.8, 1.5), (0.9, 1.5), (1, 1.5)
: c Fraction__decrease_from_repression = GRAPH(Guard_repression)
(0, 0), (0.1, 0.01), (0.2, 0.01), (0.3, 0.02), (0.4, 0.03), (0.5, 0.08), (0.6, 0.24), (0.7, 2.835), (0.8, 3), (0.9, 3), (1, 3)
: c Fraction_decrease_in_resistance = Fraction_decrease_from_fear + Fraction__decrease_from_repression
: f Decrease__in_resistance = Prisoner_resistance * Fraction_decrease_in_resistance
: c Impact_of_fear__on_unity_decrease = GRAPH(Prisoner_fear)
(0, 1), (0.1, 1.472), (0.2, 1.825), (0.3, 2.65), (0.4, 3.947), (0.5, 5.833), (0.6, 10.667), (0.7, 19.321), (0.8, 26.133), (0.9, 29.263), (1, 30)
: c Time_for_unity__to_dissolve = 3

: f Decrease__in_unity = (Prisoner__solidarity / Time_for_unity__to_dissolve) *
Impact_of_fear__on_unity_decrease
: c Impact_of_fear__on_resistance = GRAPH(Prisoner_fear)
(0, 1), (0.1, 1), (0.2, 0.987301587302), (0.3, 0.946031746032), (0.4, 0.88253968254), (0.5, 0.8), (0.6, 0.65),
(0.7, 0.445), (0.8, 0.275), (0.9, 0.11746031746), (1, 0)
: c Impact_of__repression__on_resistance = GRAPH(Guard_repression)
(0, 0), (0.1, 0.47619047619), (0.2, 0.736507936508), (0.3, 0.869841269841), (0.4, 0.92), (0.5, 0.97), (0.6,
0.985), (0.7, 1), (0.8, 1), (0.9, 1), (1, 1)
: c Indicated__resistance = Impact_of__repression__on_resistance * Impact_of_fear__on_resistance
: c Time_to__change_resistance = 1
: c Willingness_to_resist = 1
: f Increase__in_resistance = ((Indicated__resistance * Willingness_to_resist) - Prisoner_resistance) /
Time_to__change_resistance
: c Indicated_unity__from_repression = GRAPH(Guard_repression)
(0, 0.87), (0.1, 0.813), (0.2, 0.72), (0.3, 0.573), (0.4, 0.374), (0.5, 0.24), (0.6, 0.15), (0.7, 0.098), (0.8, 0.053),
(0.9, 0.012), (1, 0)
: c Tendency_to_stand_together = 1
: c Time_to__change_unity = 1
: f Increase__in_unity = ((Indicated_unity__from_repression * Tendency_to_stand_together) -
Prisoner__solidarity) / Time_to__change_unity
: c Fear_prediction = 0
: c Guard_Distrust_Prediction = GRAPH(TIME)
(0, -1), (1.5, -1), (3, -1), (4.5, -1), (6, -1), (7.5, -1), (9, -1), (10.5, -1), (12, -1), (13.5, -1), (15, -1)
: c Guard_Repression_Prediction = GRAPH(TIME)
(0, -1), (1.5, -1), (3, -1), (4.5, -1), (6, -1), (7.5, -1), (9, -1), (10.5, -1), (12, -1), (13.5, -1), (15, -1)
: c Prisoner_Fear_Prediction = GRAPH(TIME)
(0, -1), (1.25, -1), (2.5, -1), (3.75, -1), (5, -1), (6.25, -1), (7.5, -1), (8.75, -1), (10, -1), (11.25, -1), (12.5, -1),
(13.75, -1), (15, -1)
: c Prisoner_Resistance_Prediction = GRAPH(TIME)
(0, -1), (1.5, -1), (3, -1), (4.5, -1), (6, -1), (7.5, -1), (9, -1), (10.5, -1), (12, -1), (13.5, -1), (15, -1)
: c Prisoner_Solidarity_Prediction = GRAPH(TIME)
(0, -1), (1.5, -1), (3, -1), (4.5, -1), (6, -1), (7.5, -1), (9, -1), (10.5, -1), (12, -1), (13.5, -1), (15, -1)

{ RUNTIME EQUATIONS }
: s Guard_distrust(t) = Guard_distrust(t - dt) + (Change_in_guard_distrust) * dt
: s Guard_repression(t) = Guard_repression(t - dt) + (Change_in__repression) * dt
: s Prisoner_fear(t) = Prisoner_fear(t - dt) + (Change_in__prisoner_fear) * dt
: s Prisoner_resistance(t) = Prisoner_resistance(t - dt) + (Increase__in_resistance - Decrease__in_resistance) *
dt
: s Prisoner__solidarity(t) = Prisoner__solidarity(t - dt) + (Increase__in_unity - Decrease__in_unity) * dt
: c Impact_of_resistance_on_perception_time = GRAPH(Prisoner_resistance / (Guard_distrust + 0.001))
(0.9, 120), (0.92, 120), (0.94, 110.933333333), (0.96, 88), (0.98, 40), (1, 8.55555555556), (1.02, 1), (1.04, 1),
(1.06, 1), (1.08, 1), (1.1, 1)
: c Guard__perception_time = Normal_guard__perception_time * Impact_of_resistance_on_perception_time
: c Impact_of_unity__on_distrust = GRAPH(Prisoner__solidarity)
(0, 0.75), (0.1, 0.761904761905), (0.2, 0.792857142857), (0.3, 0.852380952381), (0.4, 0.969047619048),
(0.5, 1.20476190476), (0.6, 1.36428571429), (0.7, 1.42857142857), (0.8, 1.46904761905), (0.9,
1.49047619048), (1, 1.5)
: b Change_in_guard_distrust = (((Prisoner_resistance * Tendency_to_distrust) - Guard_distrust) *
Impact_of_unity__on_distrust)/ Guard__perception_time
: c Impact_of_unity__on_fear = GRAPH(Prisoner__solidarity)
(0, 1), (0.1, 0.979), (0.2, 0.958), (0.3, 0.932), (0.4, 0.903), (0.5, 0.866), (0.6, 0.831), (0.7, 0.785), (0.8, 0.76),
(0.9, 0.75), (1, 0.75)
: c Indicated_fear__from_repression = GRAPH(Guard_repression)

(0, 0.00952380952381), (0.1, 0.02), (0.2, 0.045), (0.3, 0.089), (0.4, 0.179), (0.5, 0.301), (0.6, 0.459), (0.7, 0.626), (0.8, 0.749), (0.9, 0.863), (1, 0.971428571429)
: c Indicated__prisoner_fear = Indicated_fear__from_repression * Impact_of_unity__on_fear
: b Change_in__prisoner_fear = ((Indicated__prisoner_fear * Tendency_to_fear) - Prisoner_fear) / Time_to_change_fear
: c Indicated_level_of_repression_by_guards = GRAPH(Guard_distrust)
(0, 0), (0.1, 0.053), (0.2, 0.122), (0.3, 0.256), (0.4, 0.439), (0.5, 0.65), (0.6, 0.772), (0.7, 0.878), (0.8, 0.939), (0.9, 0.976), (1, 1)
: b Change_in__repression = ((Indicated_level_of_repression_by_guards * Willingness_to_repress) - Guard_repression) / Time_to_change__repressiveness
: c Fraction_decrease_from_fear = GRAPH(Prisoner_fear)
(0, 0), (0.1, 0.02), (0.2, 0.065), (0.3, 0.23), (0.4, 0.445), (0.5, 1), (0.6, 1.3275), (0.7, 1.5), (0.8, 1.5), (0.9, 1.5), (1, 1.5)
: c Fraction__decrease_from_repression = GRAPH(Guard_repression)
(0, 0), (0.1, 0.01), (0.2, 0.01), (0.3, 0.02), (0.4, 0.03), (0.5, 0.08), (0.6, 0.24), (0.7, 2.835), (0.8, 3), (0.9, 3), (1, 3)
: c Fraction_decrease_in_resistance = Fraction_decrease_from_fear + Fraction__decrease_from_repression
: f Decrease__in_resistance = Prisoner_resistance * Fraction_decrease_in_resistance
: c Impact_of_fear__on_unity_decrease = GRAPH(Prisoner_fear)
(0, 1), (0.1, 1.472), (0.2, 1.825), (0.3, 2.65), (0.4, 3.947), (0.5, 5.833), (0.6, 10.667), (0.7, 19.321), (0.8, 26.133), (0.9, 29.263), (1, 30)
: f Decrease__in_unity = (Prisoner__solidarity / Time_for_unity__to_dissolve) * Impact_of_fear__on_unity_decrease
: c Impact_of_fear__on_resistance = GRAPH(Prisoner_fear)
(0, 1), (0.1, 1), (0.2, 0.987301587302), (0.3, 0.946031746032), (0.4, 0.88253968254), (0.5, 0.8), (0.6, 0.65), (0.7, 0.445), (0.8, 0.275), (0.9, 0.11746031746), (1, 0)
: c Impact_of__repression__on_resistance = GRAPH(Guard_repression)
(0, 0), (0.1, 0.47619047619), (0.2, 0.736507936508), (0.3, 0.869841269841), (0.4, 0.92), (0.5, 0.97), (0.6, 0.985), (0.7, 1), (0.8, 1), (0.9, 1), (1, 1)
: c Indicated__resistance = Impact_of__repression__on_resistance * Impact_of_fear__on_resistance
: f Increase__in_resistance = ((Indicated__resistance * Willingness_to_resist) - Prisoner_resistance) / Time_to__change_resistance
: c Indicated_unity__from_repression = GRAPH(Guard_repression)
(0, 0.87), (0.1, 0.813), (0.2, 0.72), (0.3, 0.573), (0.4, 0.374), (0.5, 0.24), (0.6, 0.15), (0.7, 0.098), (0.8, 0.053), (0.9, 0.012), (1, 0)
: f Increase__in_unity = ((Indicated_unity__from_repression * Tendency_to_stand_together) - Prisoner__solidarity) / Time_to__change_unity
: c Guard_Distrust_Prediction = GRAPH(TIME)
(0, -1), (1.5, -1), (3, -1), (4.5, -1), (6, -1), (7.5, -1), (9, -1), (10.5, -1), (12, -1), (13.5, -1), (15, -1)
: c Guard_Repression_Prediction = GRAPH(TIME)
(0, -1), (1.5, -1), (3, -1), (4.5, -1), (6, -1), (7.5, -1), (9, -1), (10.5, -1), (12, -1), (13.5, -1), (15, -1)
: c Prisoner_Fear_Prediction = GRAPH(TIME)
(0, -1), (1.25, -1), (2.5, -1), (3.75, -1), (5, -1), (6.25, -1), (7.5, -1), (8.75, -1), (10, -1), (11.25, -1), (12.5, -1), (13.75, -1), (15, -1)
: c Prisoner_Resistance_Prediction = GRAPH(TIME)
(0, -1), (1.5, -1), (3, -1), (4.5, -1), (6, -1), (7.5, -1), (9, -1), (10.5, -1), (12, -1), (13.5, -1), (15, -1)
: c Prisoner_Solidarity_Prediction = GRAPH(TIME)
(0, -1), (1.5, -1), (3, -1), (4.5, -1), (6, -1), (7.5, -1), (9, -1), (10.5, -1), (12, -1), (13.5, -1), (15, -1)

{ TIME SPECS }
STARTTIME=0
STOPTIME=14
DT=0.03125
INTEGRATION=RK4
RUNMODE=NORMAL
PAUSEINTERVAL=INF

Appendix B: Example Student Test Run and Response

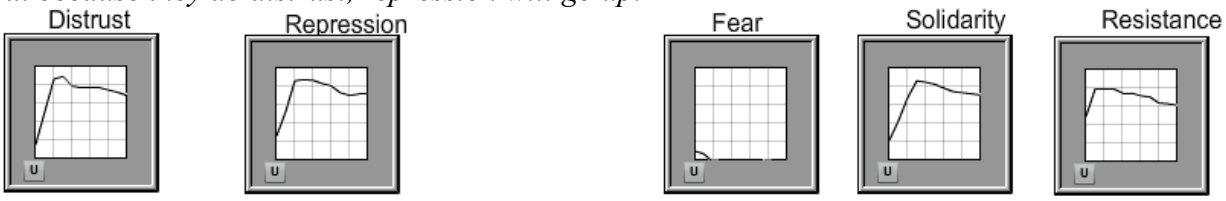
Note: Predictions on the graphs are in red. Student responses are in italics.

Run 3:

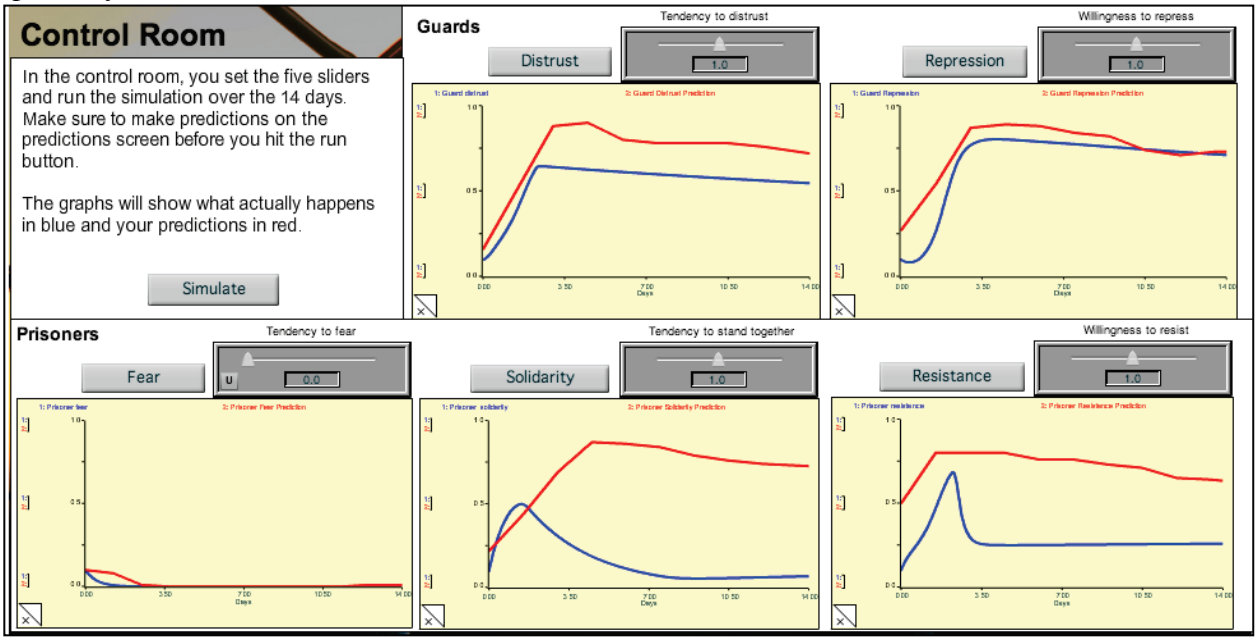
1. Variable Changed: *Fear*

2. Setting: *0.0*

3. Prediction: How do you think the five variables will change over time compared to the baseline run? Draw your predictions on the prediction screen or describe them here.
Because the fear is down they won't be afraid to resist, so resistance and solidarity will go up, but because they do distrust, repression will go up.



4. After running, describe what actually happened in comparison to the base run. [insert a copy of the graphs, either on paper or electronically.]
Distrust and repression were close to what I expected, but the solidarity and resistance shoots up, then falls.



5. Why did this happen?
I get why distrust and repression go up and slowly go down, but I keep getting the resistance and solidarity wrong. I probably am not thinking about that when they go up and the distrust and repression go up, they are going to fall.

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