Classroom Behavior

New Mexico Supercomputing Challenge
Final Report
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Team 13

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1. *Introduction*

Science has longed for the ability to measure human qualities and societies as a whole. The big question of why it is we act a certain way has had us wondering for centuries. The fact that there isn't numerical data able to measure the interactions and behaviors of people does not mean it is not a field worth researching and conducting experiments. Science is defined as the application of facts of principles or knowledge. This project focuses on the principles and the application of the behaviors of individuals. More specifically, it models the behavior of students within a high school setting and its possible epidemiological characteristics.

2. *Executive Summary*

The issue of high school student behavior and discipline is a very under-studied area within the world of education. Virtually all of the reputed research amounted to a little more than anecdotal stories. In our first stages of research, there were almost no articles available that could be regarded as serious research efforts dealing with student behavior in the classroom. While this lack of research data would normally bring the doom of a computational science project supporting to study the phenomenon of student behavior, this project actually focuses on the means by which behavior is transmitted from one student to another. We wish to model what *could* happen were student behavior in the classroom an epidemic.

Research in the area showed that students were greatly influenced by their peers. These findings lead us to conduct a survey aimed towards our fellow senior class. We asked questions pertaining to the number of friends they had and exactly how much influence they had on them. After further analysis, we used this data to apply to our model to justify our conclusions.

Classroom behavior takes into account certain characteristics that define the effects and results of a certain behavior. Level of strictness of a teacher is one example; susceptibility of a teacher and/or student is another crucial factor. What is the infection rate and other factors in which these behaviors are spread?

3. *Problem Statement*

The objective of this project is to demonstrate a correlation involving behavioral issues in students and the possible epidemiological-like effects this conduct will have in a classroom. We have modeled the tendency in which students adopt behaviors within an environment depending on the factors they encompass and their levels of personal traits, singled out to enhance the authenticity of the program.

By enhancing the characteristics of the agents and manipulating how they behave, an artificial society is created. According to JASSS, an "'Artificial society' refers to an agent-based simulation model used to discover global social structures and collective behavior produced by simple local rules and interaction mechanisms[1] ." Agents work for a specific cause; to bring about a desired result using plausible variables and methods.

[1] Barry G. Lawson and Steve Park: Asynchronous Time Evolution in an Artificial Society Model." Web. 10 Dec. 2009. <http://jasss.soc.surrey.ac.uk/3/1/2.html>.

4. *Overview*

The significance of this project is merely to open up new opportunities and continue to research this understudied field. Consequently, this research could help any behavioral issue within a society or a group including differing personalities and varying environments. For example, teachers may learn to better understand the significance of seat arrangements and student personalities within a classroom[2]. Certain networks created in different instances can alter the resulting behavior of a person or a group as a whole. Teachers may come to realize the importance of placement and strictness in a scholarly environment.

The idea of studying social behavior and the effects of one person to another is an area that lacks concrete research and previous study. The study conducted and the results produced have been strictly defined by various interpretations of data. It is crucial that the possibilities as well as limitations of social science are discovered. While certain characteristics must be modified logically, the vast amount of information available is vital in determining correlations that will determine the legitimacy of a program or study.

The concept regarding spread of behaviors within a network can even be taken so far into the work force, where contractors seek to control the behavior of their employees in order to maximize the efficiency and outcome of their labor.

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[2] Epstein, Joshua M. "Q&A With Joshua Epstein on Computational Modeling." Interview. Brookings, 18 Mar. 2008. Web. 1 Mar. 2010. < http://www.brookings.edu/interviews/2008/0319_csed_epstein.aspx>

5. *Computational Model*

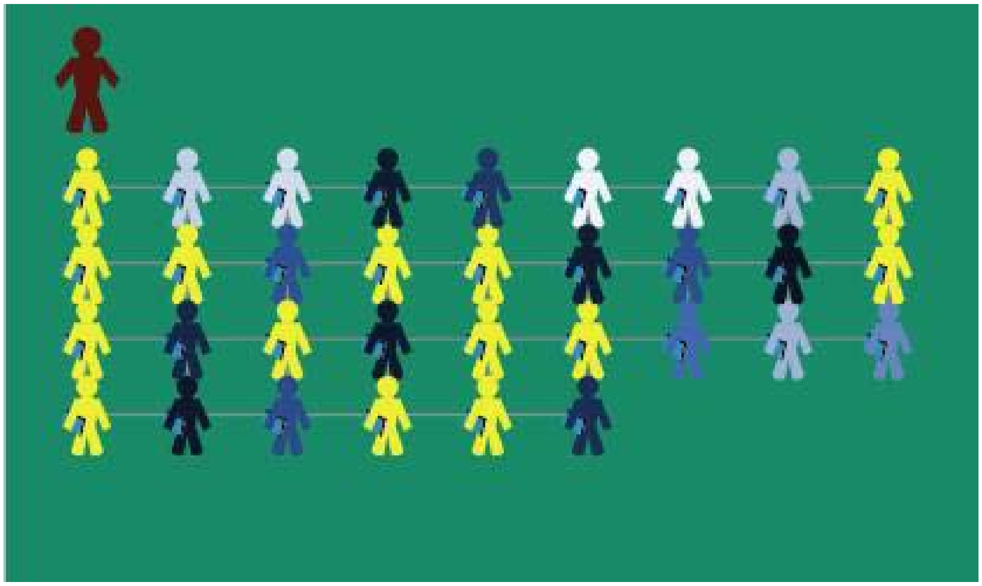

Figure 1

As previously stated, the limitations of the program include nine classrooms. These nine classrooms consist of students (books and all). At random, they are asked to go a different classroom at the beginning of every period. The period, for the sake of the program, is controlled by a slider. The number of ticks, controlled by that slider, per period can range from 1 to 10. The ticks do not represent time, however. Each tick more realistically represents the number of behaviors participated in before the students are once again asked to go another class at random.

A teacher is located in the top left-hand corner within each classroom. The teachers have strictness levels ranging from .3 to .8. These boundaries were chosen keeping in mind the fact that in reality there aren't necessarily teachers who do not possess the power to control their students at all, and also that there are not necessarily teachers who have a complete authority over all of their students. The teacher's strictness level determines the color for that specific teacher. The darkest red of teachers is the strictest. The lightest red, or pink, teachers exhibit least strict impressions.

The next element in the model is the students. Upon entering a classroom, the students are immediately connected by a network of links. These links hold a numerical quantity of conductivity which controls the means by which their “infection” or behaviors are spread. If a student is connected to a strict teacher, that student is less likely to participate in behavior and

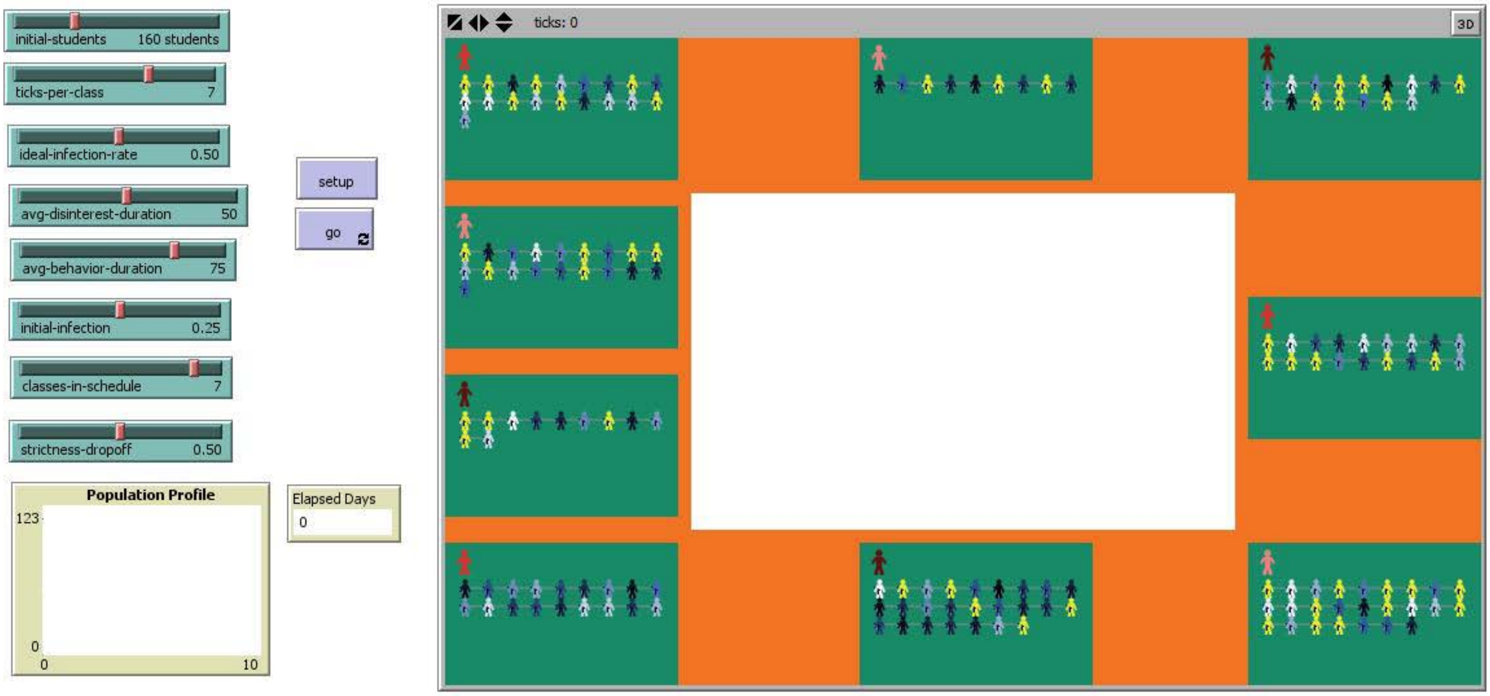

Figure 2

will have a low susceptibility. Vice versa, a student farthest away or the most links away will more likely be participating in the behavior, or will be infected according to the ideal infection formula.

The strictness of the teachers is static. Three of them exhibit strictness of .3 (pink); the next three exhibit strictness of .5 (red); the last three exhibit strictness of .8 (dark red). This is to show and test the diverse, yet definite, characteristics of teachers.

The program also only takes into account the influences within the school and not outside of the latter. The networks created are only peculiar to those belonging to a classroom setting.

6. *Methods*

In order to model a classroom setting, and networks within, to emulate an epidemic, an SIR model is critical to perceive the outcome of the dissemination of different behaviors. Susceptible, infected, and recovered are three of the four characteristics of the agents present in the model. The fourth characteristic is “disinterested” which we have used to represent the vanishing of fads that occur too often in the younger population, especially in school where one’s social life suggests acceptance among peers.

The program used to model this phenomenon is Netlogo, in which an artificial society is created to simulate epidemiological isolation, inoculation, and immunization. Isolation is defined as, in correspondence to our model, the complete separation from others of a person suffering from contagious or infectious disease (quarantine). Inoculation is introduction of antigenic substance or vaccine into the body to produce immunity to a specific disease. Finally, immunization is the process by which resistance to disease is acquired or induced. These terms apply to the transmission of behavior in matters of principle, not literal, senses. We can replace certain aspects of the epidemiological process with alternative methods in which we have defined. For example, the role of inoculation in our model could best stand for the general rules of high school setting. These rules play a dampening effect in bad behavior.

According to *MSN News*, friends with constructive habits are healthy to have around. They explain that,

> “People tend to mimic the behavior of those around them, and bad habits such as smoking, drug use and obesity tend to spread through social networks. But the current study is thought to be the first to show that self-control is contagious across behaviors. That means that thinking about someone who exerts self-control by regularly exercising,

for example, can make you more likely to stick with your financial goals, career goals or anything else that takes self-control on your part[3]."

Our model is not explicit on the form of behaviors transmitted, that is, positive or negative. Conversely, it identifies both of these behaviors as being able to be transmitted, not by their denomination, but by the influence they exert depending on the relations between both individuals. Duke University vindicates the impression of close relations among individuals. They explain that if "…you identify with someone, say you want to be a Wall Street-type like Madoff, in these cases our research shows that you are more likely to emulate their unethical behaviors[4]." Our behaviors can definitely be swayed by how we judge the people around us.

[3] "Self-control -- or Lack of It -- Is Contagious." *Breaking News, Weather, Business, Health, Entertainment, Sports, Politics, Travel, Science, Technology, Local, US & World News- Msnbc.com*. 15 Jan. 2010. Web. 23 Feb. 2010. <http://www.msnbc.msn.com/id/34881243/ns/health-behavior>.

[4] "Contagious Dishonesty: How One Bad Apple Can Ruin the Barrel - Duke's Fuqua School of Business." *Duke University's Fuqua School of Business*. 12 Apr. 2009. Web. 23 Feb. 2010. <http://www.fuqua.duke.edu/news_events/archive/2009/ariely_bad_apples

7. Mathematical Model

$$
\begin{array}{ccc}
\text{S} & = & \text{\# Susceptible} \\
\text{I} & = & \text{\# Infected} \\
\text{R} & = & \text{\# Recovered} \\
t & = & \text{time} \\
r & = & \text{rate of infection} \\
P & = & \text{Population}
\end{array}
$$

$$
\begin{aligned}
I_{t+1} &= r_I \left[\frac{I_t \times S_t}{P}\right] + I_t \\
I_{t+1} &= r_I \left[\frac{I_t \times S_t}{P}\right] + I_t - R_r I_t \\
S_{t+1} &= S_t - r_I \left[I_t \frac{S_t}{P}\right] + r_s R_t \\
R_{t+1} &= R_t + r_R I_t - r_s R_t
\end{aligned}
$$

Infected

Infected takes into account all the students who portray a certain behavior. They have neither recovered, and aren't susceptible or disinterested. The program only renders representations for one behavior at a time. The agents can't execute more than this because the SIR attributes would intervene and possibly interfere with another behavior, which would prove to be incorrect and lacking research.

The next infected equation takes into account the number of individuals who have recovered or lost interest in a certain fad (disinterested). By subtracting this number we eliminate those who are no longer infected or susceptible.

Susceptible

Susceptible indicates the number of students who aren't yet infected, but have a possibility to be. They have been recovered, but are not disinterested.

Recovered

Recovered indicates the number of students who aren't infected, but may or not be susceptible. Depending on the time after they recover, the initial infection rate and conductivity, the agents may or may not last in this category for long.

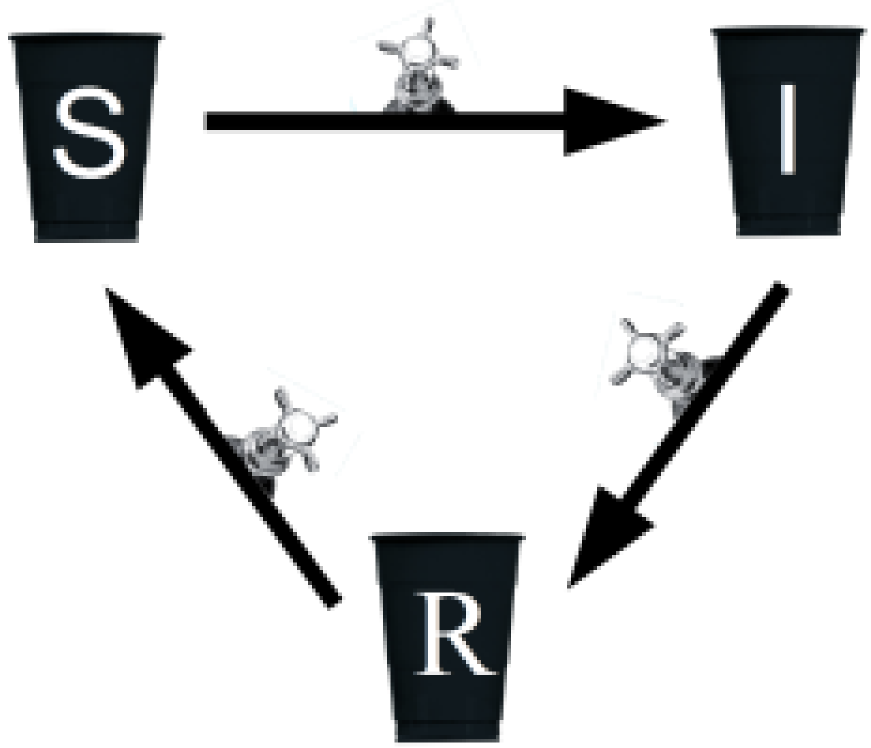

Figure 3

Explanation

$$S_t + I_t + R_t = P$$

The number of susceptible, infected, and recovered should all equal to the population number. In this SIR model, there are no “disinterested” because the disinterested can’t get infected until they become susceptible again. However, this cycle explains most of our tendencies to recover and to get infected. Therefore, “disinterested” here should be part of the “susceptible” category, since it doesn’t correlate with Infected or Recovered.

$$s_t = \mathrm{S}/P \qquad \mathrm{i}_t = \mathrm{I}/P \qquad \mathrm{r}_t = \mathrm{R}/P$$

$$s_t + i_t + r_t = 1$$

By dividing the number of susceptible by the population, and likewise the number of infected and recovered in the same manner, the percentage of each of these is obtained. Adding all three quantities should always yield 1.

The following is the mathematical equation to decipher the percentage of the chance of infection of a particular behavior:

- (charisma)(conductivity)(susceptibility)(infection rate) = chance of infection.
- Charisma – numerical value from .1 to 1 defining the level of influence over large numbers of people
- Conductivity – numerical value from .1 to 1 defining the rate of transmission or resistance to the influence of students
- Susceptibility – numerical value from .1 to 1 defining the capability of being affected by the behavior exhibited by the students

- Infection rate – numeral value from .1 to 1 defining the parameter of how likely one is to become infected
    - i.e.
        - (0.6)(.07)(.04)(1)= .168 = 16.8% chance of infection
        - (1)(1)(1)(1) = 1 = 100% perfect transmission of infection

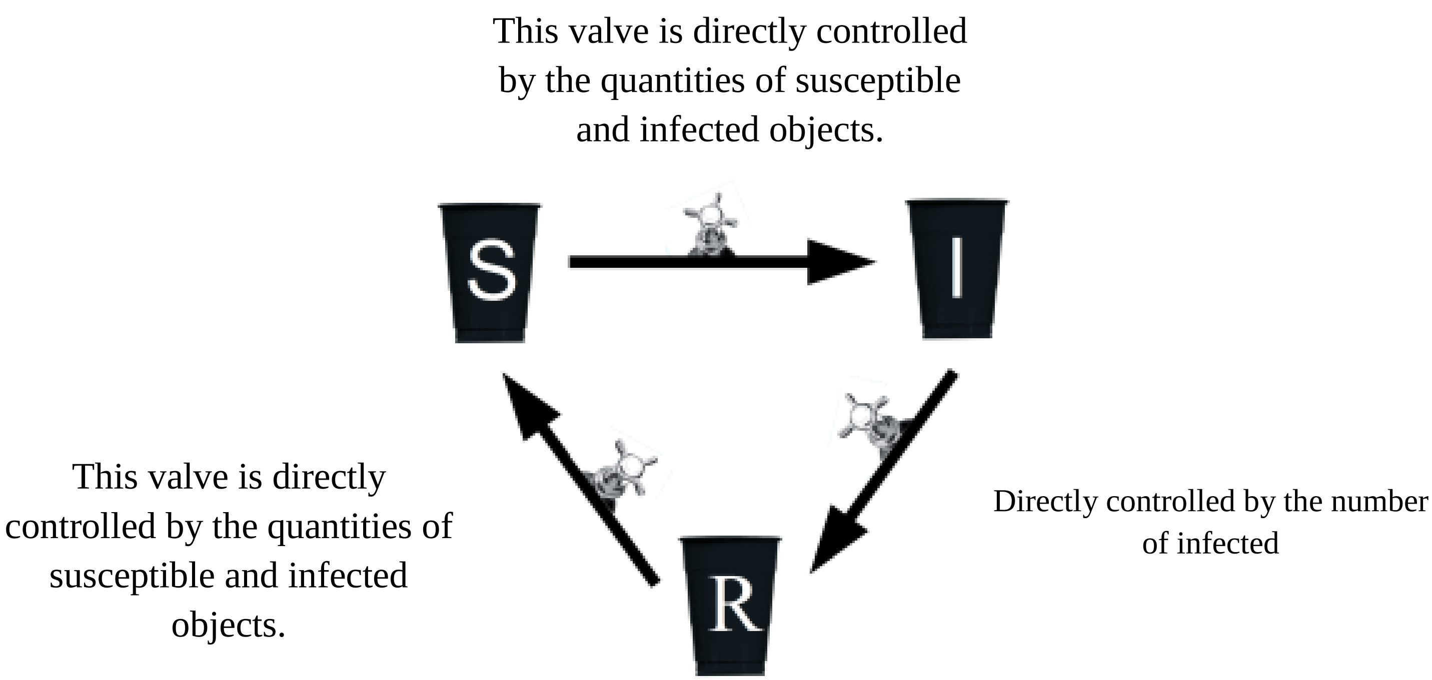

Figure 4

According to Epstein, numerous articles claim that a social phenomenon is established to be equilibrium, usually a Nash equilibrium. “The Nash equilibrium concept is used to analyze the outcome of the strategic interaction of several decision makers. In other words, it is a way of predicting what will happen if several people or several institutions are making decisions at the same time, and if the decision of each one depends on the decisions of the others. The simple insight underlying John Nash's idea is that we cannot predict the result of the choices of multiple decision makers if we analyze those decisions in isolation. Instead, we must ask what each player would do, *taking into account* the decision-making of the others[5].”

[5] "Nash Equilibrium." *Wikipedia, the Free Encyclopedia*. Web. 07 Apr. 2010. <http://en.wikipedia.org/wiki/Nash_equilibrium>.

He goes on to explain that “it is fair to say that, overwhelmingly, game theory, mathematical economics, and rational choice political science are concerned with equilibriums”[6]. There are three cases where the Nash equilibrium won’t be “deeply revealing”.

1. The phenomenon of interest is a nonequilibrium dynamic
2. Equilibrium is attainable in principle, but not on acceptable time scales
3. Equilibrium exists but unattainable outright

[6] Epstein, Joshua M. *Generative Social Science Studies in Agent-Based Computational Modeling (Princeton Studies in Complexity)*. New York: Princeton UP, 2007. Print.

8. *References*

"Barry G. Lawson and Steve Park: Asynchronous Time Evolution in an Artificial Society Model." Web. 10 Dec. 2009. <http://jasss.soc.surrey.ac.uk/3/1/2.html>.

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"Nash Equilibrium." *Wikipedia, the Free Encyclopedia*. Web. 07 Apr. 2010. <http://en.wikipedia.org/wiki/Nash_equilibrium>.

"Self-control -- or Lack of It -- Is Contagious." *Breaking News, Weather, Business, Health, Entertainment, Sports, Politics, Travel, Science, Technology, Local, US & World News-Msnbc.com*. 15 Jan. 2010. Web. 23 Feb. 2010. <http://www.msnbc.msn.com/id/34881243/ns/health-behavior>.

9. *Results*

We first noticed that no students were infected when the teachers' "strictness drop off" was only: .1. This test was ran for the sake of logic and proved to perfectly model the real world. There were no students infected when the "strictness drop off" was: .5. Just like in a real classroom, the students would not participate in behaviors when their teachers were very enforcing of their rules. In the next period of tests, the strictness drop off was changed to 1,

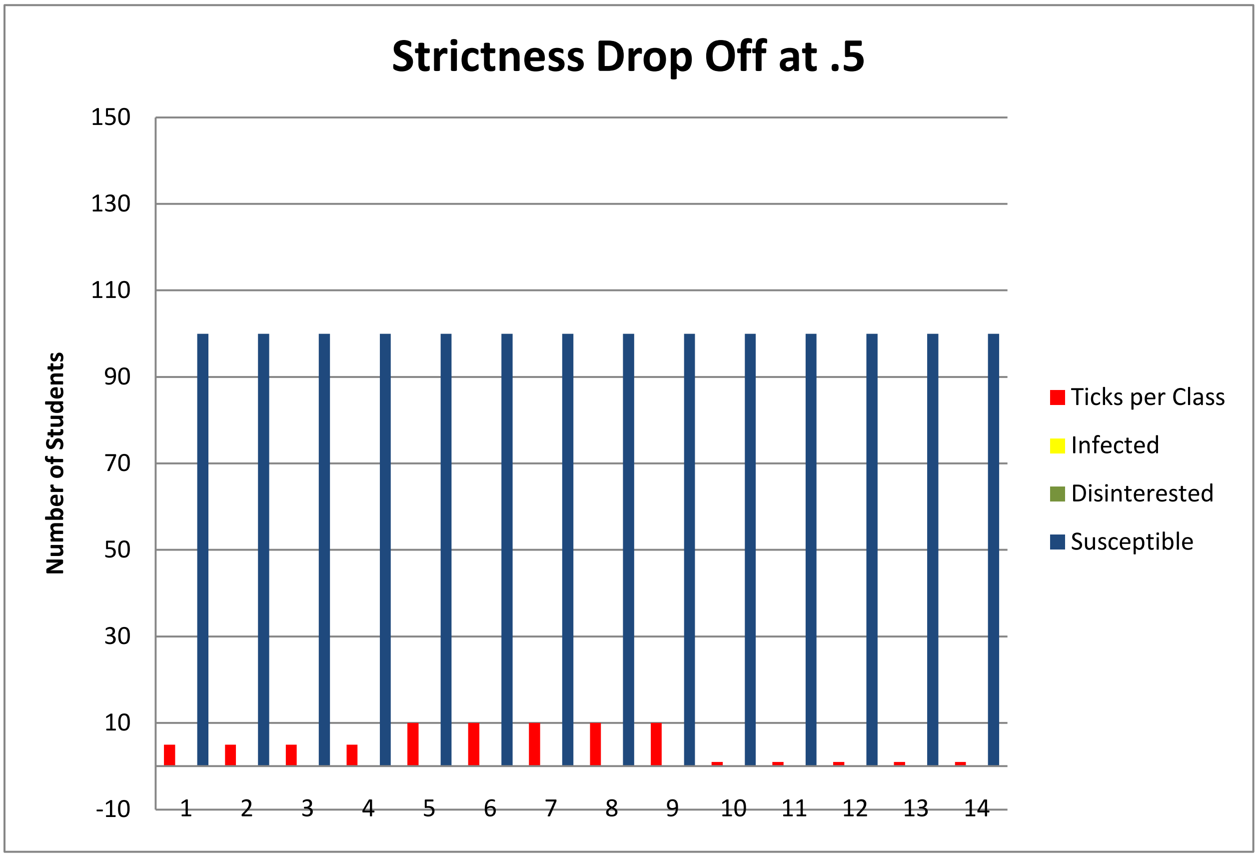

Figure 5

which is the maximum for that slider; it was from this point on that students immediately became infected or began participating in behavior as their teachers then held back their strictness levels so students began rebelling against all previous notions.

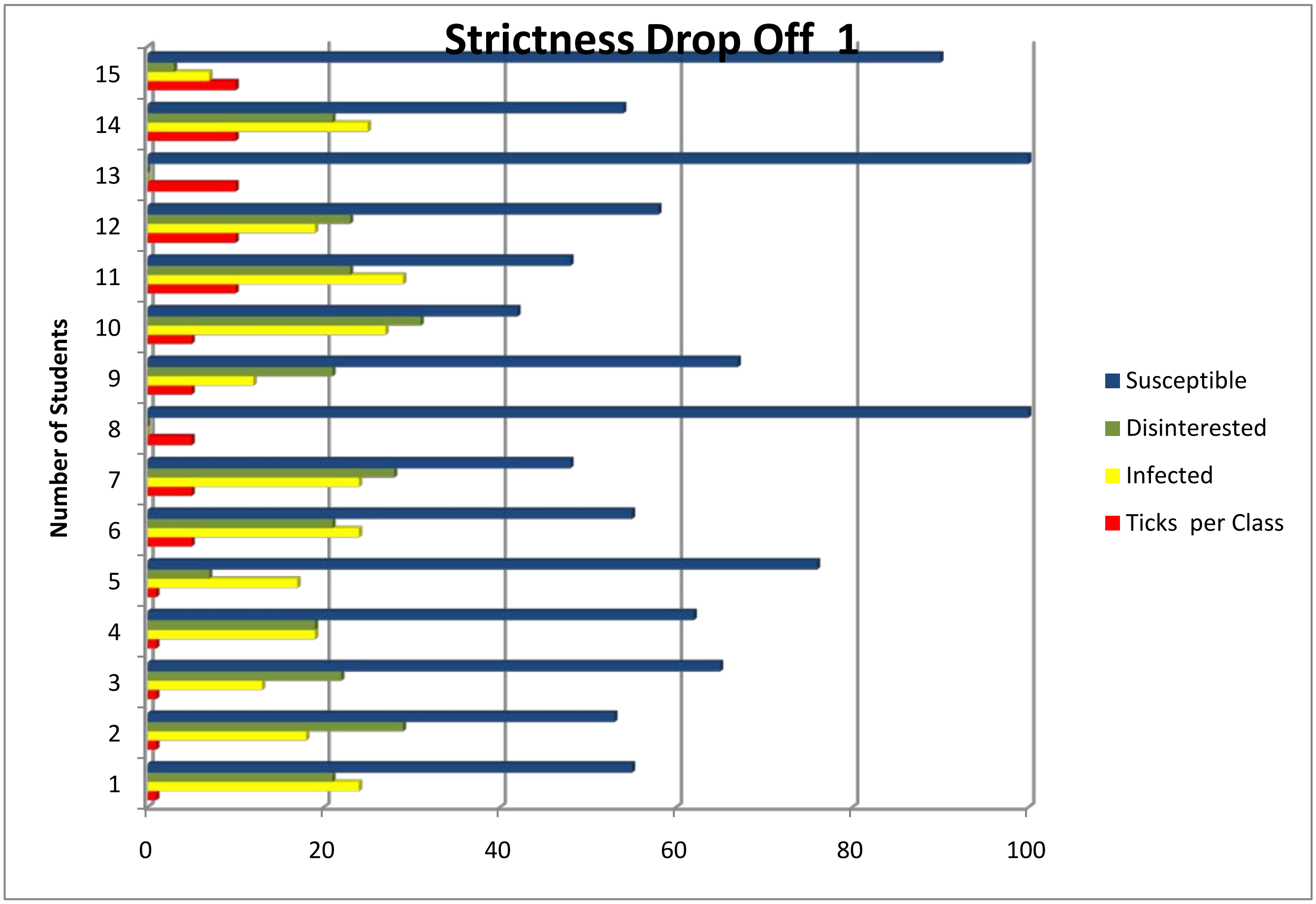

Figure 6

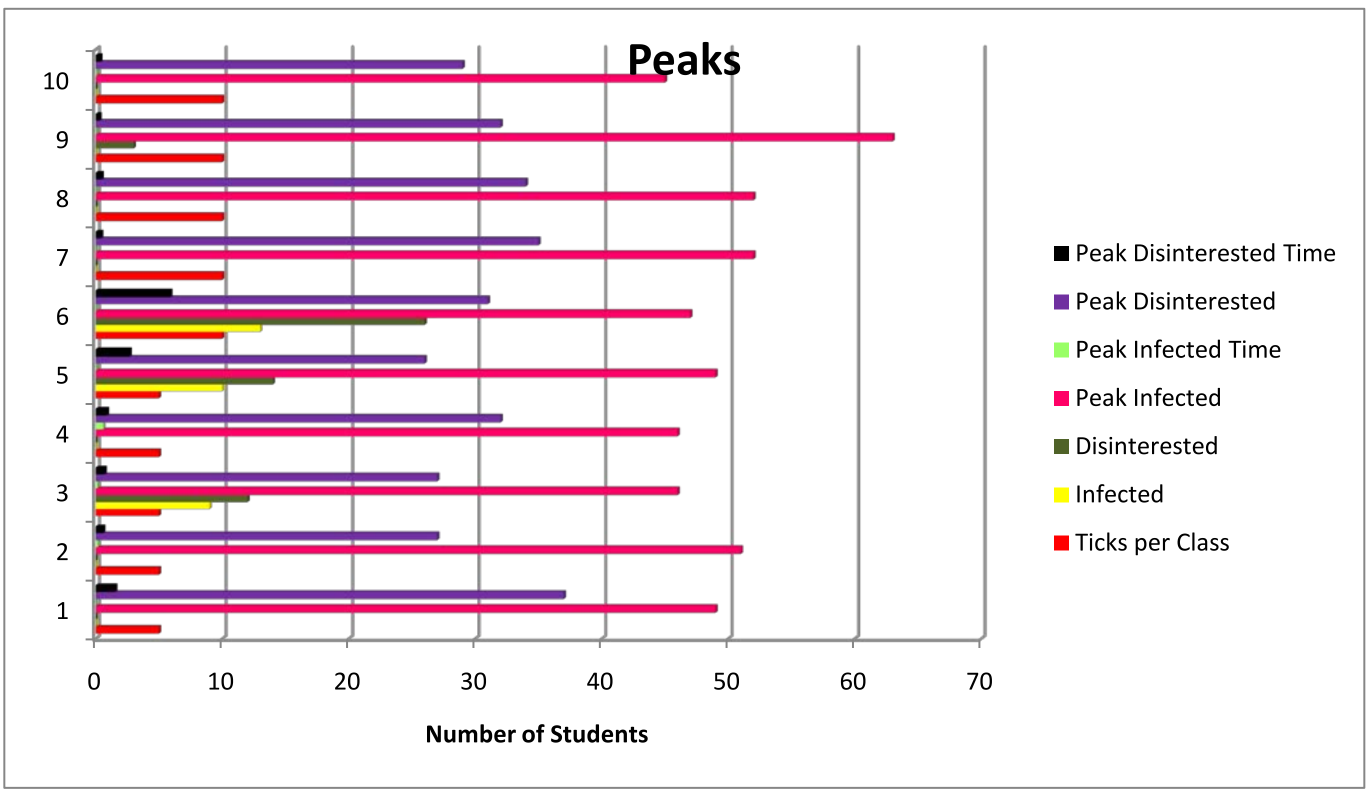

Figure 7

The next series of experiments ran on the model were to keep account for when different categories peaked to their highest. As Figure 7 shows, the highest number ever infected was a little more than 60 when the number of ticks was also at its highest, 10. This number was at 60 when there were 100 students within the school and the strictness drop off was at 1.

10.Conclusion

This model offers a new way to interpret the dynamics of behavior in the classroom. With this, the model intends to effectively form ways to better control the behavior of students with efficient policies, such as seating arrangements and the networks in which students are exposed. With continual research and experiment, this theory can be taken into any world of hierarchy where discipline and rebellion have become issues. Each of the objects studied within this model can be represented in almost any scenario and the principles applied can be used to more understand the human mind and the tendencies in which it displays.

11 Appendix A

11.1 Annotated Bibliography

"Bad Behavior Contagious, Study Finds - CBS News." *Breaking News Headlines: Business, Entertainment & World News - CBS News*. 21 Nov. 2008. Web. 07 Apr. 2010. <http://www.cbsnews.com/stories/2008/11/21/tech/main4623773.shtml?tag=mncol;lst;1>

This article presented a lot of anecdotal stories and tests that were run to emphasize the impact other people have on individuals. However, this was all it provided. It contained no mathematical data, statistics, etc.

"How do epidemics induce behavioral changes?" *IDEAS: Economics and Finance Research*. Web. 8 Dec. 2009. <http://ideas.repec.org/p/gla/glaewp/2007_25.html>.

It talked about diseases such as malaria and HIV/AIDS but described its effect on economic behavior and fertility, which didn't supply relevant information for our paper.

12 Appendix B

12.1 Questionnaire

> "Agent-based modelers may use statistics to gauge the generative sufficiency of a given micro specification—to test the agreement between real-world and generated macro structures[7]." -Joshua Epstein

To have a better understanding of how networks are perceived by students, a questionnaire was created and handed out to seven senior economics classes.

The following is the questionnaire was used for our research:

[7] Epstein, Joshua M. *Generative Social Science Studies in Agent-Based Computational Modeling (Princeton Studies in Complexity)*. New York: Princeton UP, 2007. Print.

Questionnaire

These questions are to help us gather data for our Computing Challenge Project. Thanks for answering them. If you have any comments that would be helpful, write them on the back.

1. How many close friends do you have at Artesia High School?

2. How many not so close friends do you have at Artesia High School?

3. How many acquaintances do you have at Artesia High School?

4. How many people would you call "NOT FRIENDS" in Artesia High School?

5. How many close friends do you have in this class?

6. How many not so close friends do you have in this class?

7. How many acquaintances do you have in this class?

8. Does the behavior of your close friends affect your behavior?
10= A great deal 0= Not at all

10 9 8 7 6 5 4 3 2 1 0

9. Does the behavior of your not so close friends affect your behavior?
10= A great deal 0= Not at all

10 9 8 7 6 5 4 3 2 1 0

10. Does the behavior of your acquaintances affect your behavior?
10= A great deal 0= Not at all

10 9 8 7 6 5 4 3 2 1 0

11. Does the behavior of your "NOT FRIENDS" affect your behavior?
10= A great deal 0= Not at all

10 9 8 7 6 5 4 3 2 1 0

Figure 8

For the majority, the results of the questionnaire support our thesis that behaviors are induced by the people closest to you. Our team even saw that students rebelled against the questions by putting vague, sarcastic answers. Some classes had a majority of students write answers such as “a lot” or “no never,” instead of actually giving a numerical value or circling one of the choices from the range of answers. Other classes, however, took the questionnaire seriously and give us real answers that we could interpret and analyze. The questionnaire unintentionally proved once again that students are affected by the networks in which they are connected and influences around them.

13 Appendix C

13. 1 Code

```
breed [teachers teacher]
breed [students student]

globals [
  peak-infected
  peak-infected-time
  peak-disinterested
  peak-disinterested-time
]

students-own [
  susceptibility      ; S,constantly changing with the amount of strictness level, rebellion ;
students classtime, ranging from 0-1 (inclusive)
  charisma           ; C, if true, then the student is rebellion ly rebelling
  class-schedule          ; how many minutes in class remain? (if 0, the student is not in
class)
  infected?
  disinterested?
  last-change
]

links-own [
 conductivity
]


teachers-own [
  strictness  ; S, also ranging from 0-1 (inclusive)
]

to setup
  clear-all
  setup-classrooms
  setup-teachers
  setup-students
  go-to-class
  update-plot
```

```
  update-stats
end

to setup-classrooms
  import-pcolors "class background.png"
end

to setup-teachers
  set-default-shape teachers "person"
  ask patches [
    if (shade-of? pcolor red) [
      sprout-teachers 1 [
        set size 2
        set color pcolor
        set pcolor mean [pcolor] of neighbors
        set strictness 1 - (color / 10 - 1)
      ]
    ]
  ]
end

to setup-students
  set-default-shape students "person student"
  create-students initial-students [
    setxy random-xcor random-ycor
    set size 1.5
    set susceptibility random-float 1
    set charisma random-float 1
    set class-schedule n-values classes-in-schedule [one-of teachers]
    set disinterested? false
    set last-change -1
    ifelse (random-float 1) < initial-infection [
      set infected? true
      set color yellow
    ]
    [
      set infected? false
      set color scale-color blue susceptibility 1 0
    ]
  ]
```

```
end

to go
  if not any? students with [infected? or disinterested?] [
    stop
  ]
  if (ticks mod classes-in-schedule) = 0 [
    go-to-class
  ]
  recover-from-disinterest
  recover-from-infection
  spread-infection
  tick
  update-plot
  update-stats
end

to go-to-class
  ask links [
    die
  ]
  ask teachers [
    let home-patch patch-here
    let class (students with [myself = first class-schedule])
    let class-list [self] of class
     let my-teacher self
    (foreach class-list (n-values length class-list [?]) [
        ask ?1 [
          let row floor (?2 / 9)
          let column ?2 mod 9
          setxy ([xcor] of my-teacher + column * 1.85) ([ycor] of my-teacher - 2 - 1.4 * row)
          if ?2 = 0 [
            create-link-with my-teacher
          ]

        ]
    ])
    ask class [
       create-links-with other class with [distance myself < 2.1]
       [
```

```
      set conductivity 1
     ]
   ]
   let closest-student [ other-end] of one-of my-links
   ask my-links [
     die
   ]
   ask [my-links] of closest-student [
     adjust-conductivity closest-student [strictness] of myself
   ]
  ]
  ask students [
   let current-class first class-schedule
   set class-schedule lput current-class but-first class-schedule
  ]
end

to adjust-conductivity [ from-student teacher-effect]
  if 1 - teacher-effect < conductivity [
    let destination one-of both-ends with [self != from-student]
    set conductivity 1 - teacher-effect
    ask other [my-links] of destination [
      adjust-conductivity destination (teacher-effect * (1 - strictness-dropoff))
    ]
  ]

end

to recover-from-disinterest
  ask students with [disinterested? and last-change < ticks and (random-float 1) <  1 /
avg-disinterest-duration] [
    set disinterested? false
    set color scale-color blue susceptibility 1 0
    set last-change ticks
  ]
end

to recover-from-infection
  ask students with [infected? and last-change < ticks and (random-float 1) <  1 / avg-
behavior-duration] [
```

```
    set infected? false
    set disinterested? true
    set color green
    set last-change ticks

  ]
end

to spread-infection
  ask links [
    if (any? both-ends with [infected? and last-change < ticks ] ) and (any? both-ends with
[not infected? and not disinterested? and last-change < ticks]) [
      let infected-student one-of both-ends with [ infected? ]
      let susceptible-student one-of both-ends with [ not infected? and not disinterested?]
      let infection-probability ideal-infection-rate * conductivity * ([charisma] of infected-
student) * ([susceptibility] of susceptible-student)
      if (random-float 1) < infection-probability [
        ask susceptible-student [
          set color yellow
          set infected? true
          set last-change ticks
        ]
      ]
    ]
  ]
end

to update-plot
  set-current-plot "Population Profile"
  set-current-plot-pen "Infected"
  plotxy elapsed-days count students with [infected?]
  set-current-plot-pen "Susceptible"
  plotxy elapsed-days count students with [not infected? and not disinterested?]
  set-current-plot-pen "Disinterested"
  plotxy elapsed-days count students with [disinterested?]

end

to-report elapsed-days
  report ticks / (ticks-per-class * classes-in-schedule)
```

```
end

to update-stats
  if count students with [infected?] > peak-infected [
    set peak-infected count students with [infected?]
    set peak-infected-time elapsed-days
  ]
  if count students with [disinterested?] > peak-disinterested [
    set peak-disinterested count students with [disinterested?]
    set peak-disinterested-time elapsed-days
  ]
end
```

14. Appendix D

14.1 Acknowledgements

We would like to acknowledge the following people:

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Mrs. Mathis

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