Social Interactions at a Public High School

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Over the summer, I worked on a project at an Epidemiology lab at the University of Utah that investigated how social interactions in elementary schools, middle schools, and high schools affected the transmission of viruses. This project identified the social networks of a highschool in Salt Lake City, Utah. Students wore sensors that recorded the length and time of each interaction, enabling me to analyze these variables. This data will help epidimeologists better determine the spread of viruses through schools.

There were four datasets downloaded in the project. The first two were the node attributes for Day 1 and Day 2. The third file was the highschool schedule enabling determination of the class period the interaction occured. The last interaction was the edgelist for both Day 1 and Day 2.

I used R packages igraph, dplyr, chron, and lubridate.

I created two datasets containing interactions occuring on either Day 1 or Day 2. I recoded the node attributes to match the edgelist in each dataset.

I then created a "Period" edge attribute to identify when each interaction occured. There were 4 periods, 3 hallway Passings, and 2 lunches. Although some students had different lunchtimes, I coded students who interacted during lunchtime but had opposite lunches in "Lunch."

Summary of Network

There were two networks for each day of the experiment. I created smallers networks for each period, hallway passing, and lunch (lunch 1 and lunch 2 were grouped together).

Day 1

```
## IGRAPH 9e702e0 UN-- 1425 153999 --
## + attr: name (v/c), GradeCat (v/n), GenderCat (v/n), Lunch (v/n),
## | TotalSeconds (e/n), BeginDateTime (e/c), EndDateTime (e/c),
## | Duration (e/n), period (e/c)
```

For day 1, there were 1425 students (vertices) who participated and 153999 interactions (edges).

Day 2

```
## IGRAPH 31a0f98 UN-- 1220 556935 --
## + attr: name (v/c), GradeCat (v/n), GenderCat (v/n), Lunch (v/n),
## | TotalSeconds (e/n), BeginDateTime (e/c), EndDateTime (e/c),
## | Duration (e/n), period (e/c)
```

For day 2, there were 1220 students who participated and 556935 interactions.

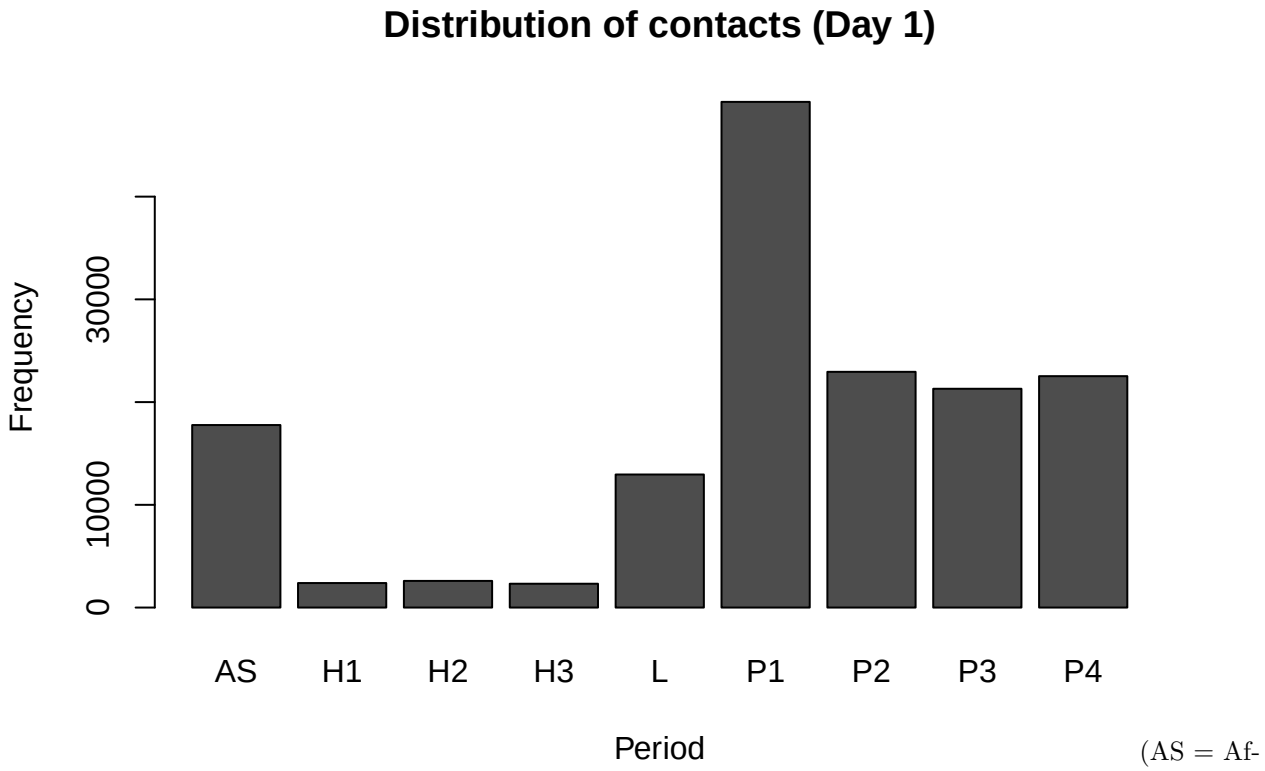
Distribution

I graphed the distribution for the number of interactions during each hallway passing, period, lunch, and after school. Since sensors were handed out to students in period 1, there was an overestimation of the number of interactions for this period on Day 1. Since sensors were collected in period 4 on Day 2, there was an overestimation of the number of interactions for this period.

For all graphs, P = Period, H = Hallway Passing, and AS = After school. Since there were four periods, P1, P2, P3, and P4 denoted periods 1-4. H1, H2, and H3 denoted hallway passings 1-3.

Day 1

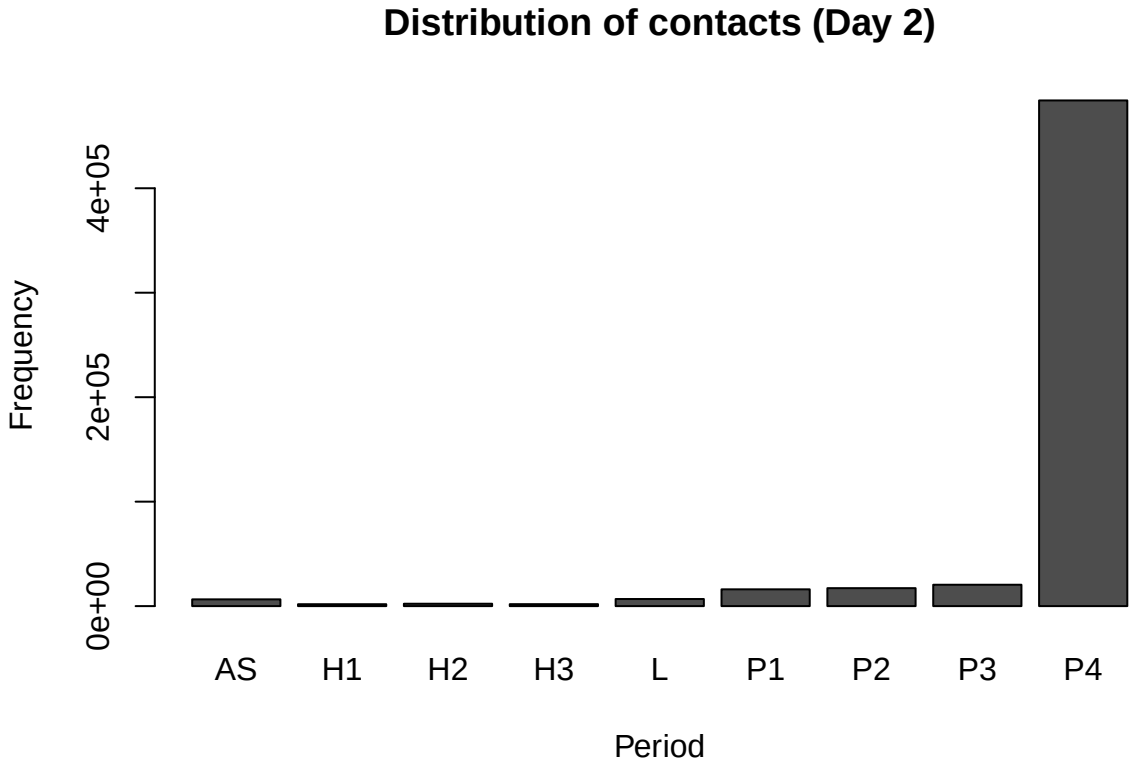
```
##  After School Hallway1 Hallway2 Hallway3 Lunch Period1 Period2 Period3 Period4
##
##         17765     2385     2592     2317 12951   49223   22944   21297   22525
```



(AS = After School)

Day 2

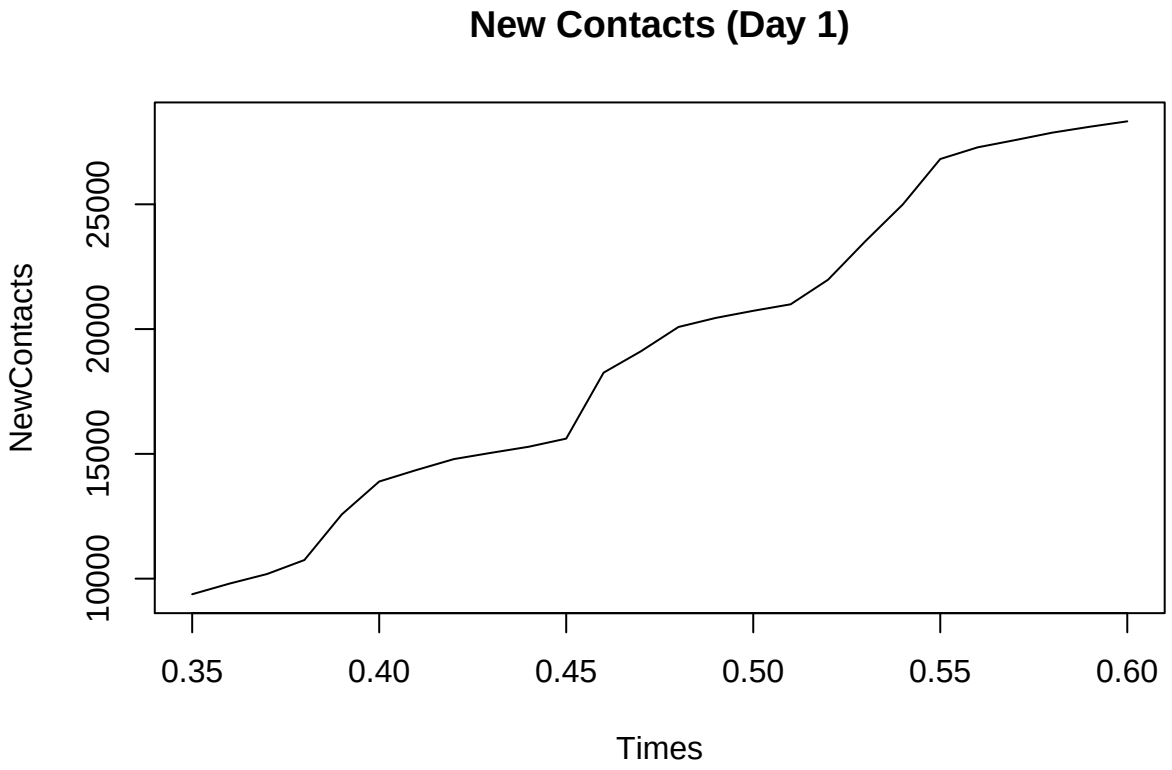
```
##  Before School Hallway1 Hallway2 Hallway3  Lunch Period1 Period2 Period3 Period4
##
##          6446     1821     2269     1863   6795   16050   17182   20441  484068
```



Interactions Throughout the Day

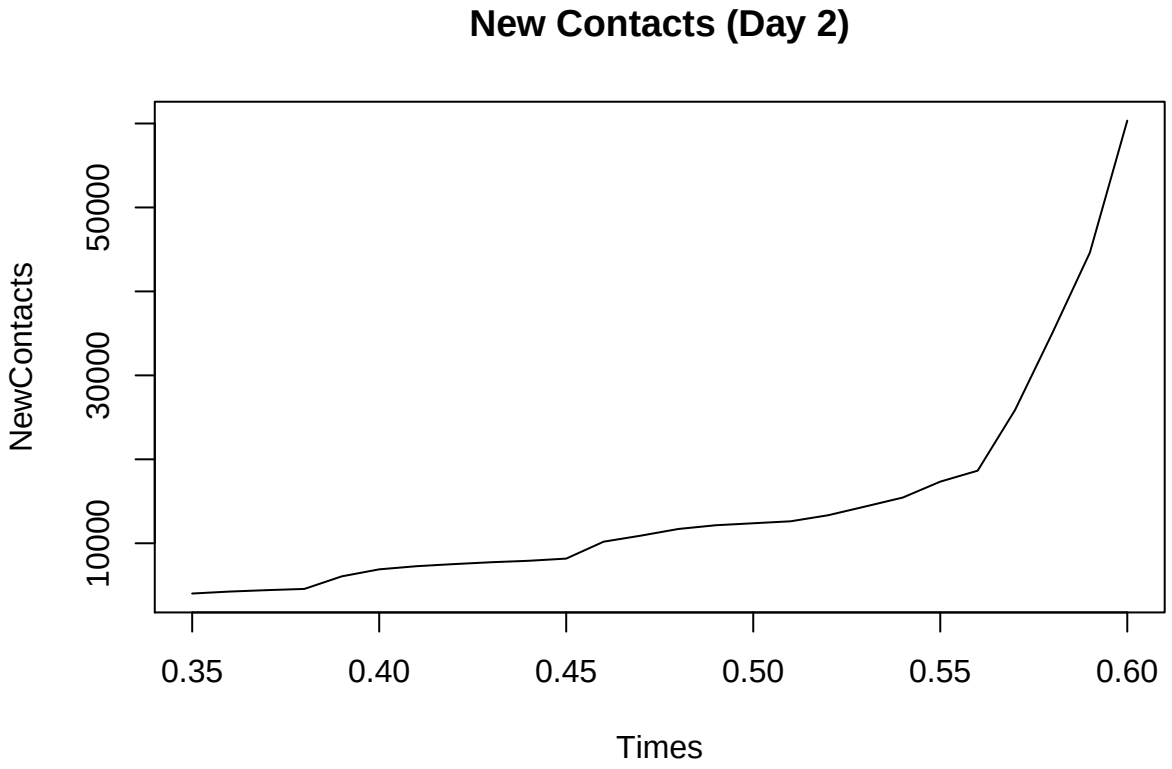
The two plots showed the new interactions as the day progressed.

Day 1



There were three step-ups in the graph representing the start of a new period or hallway passing. This occured since students were more likely to interact with other students they had not seen yet.

Day 2



I examined different social networking attributes including degree, betweenness, closeness, transitivity, density

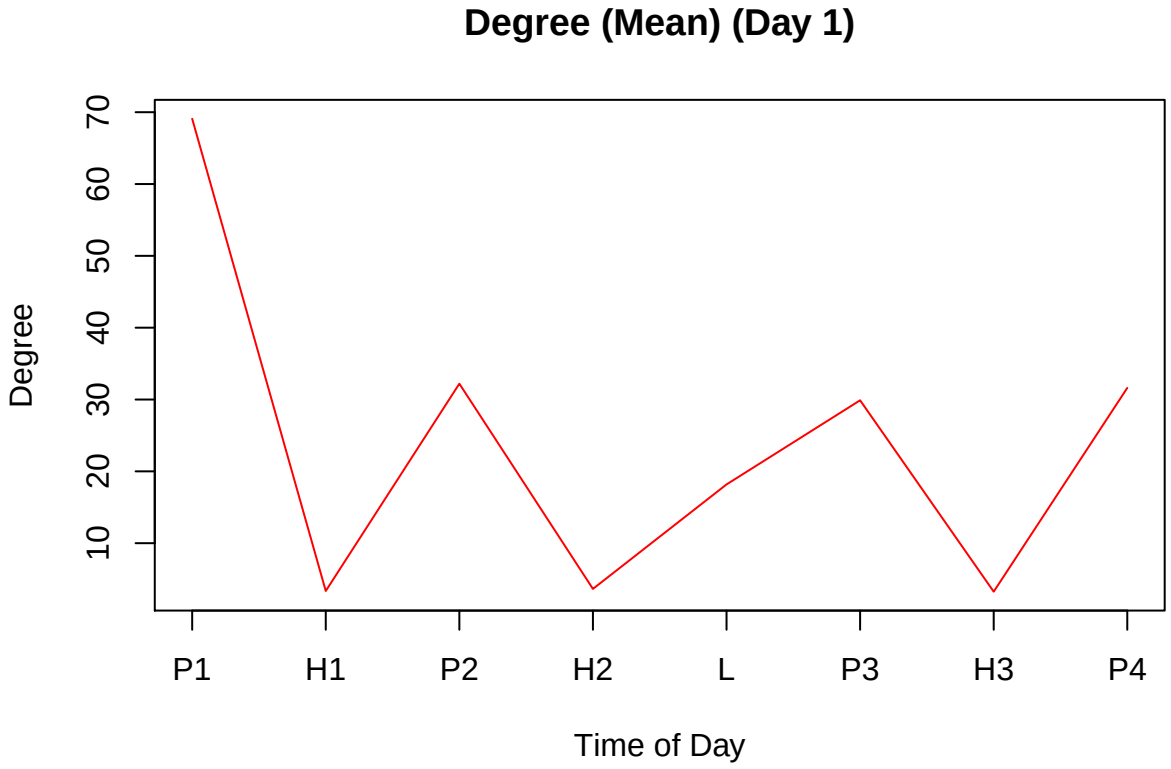
and assortativity. For degree, betweenness, and closeness, transitivity, and density I used the same technique to code the graphs and tables.

Degree

Degree represented the number of edges for each node.

Day 1

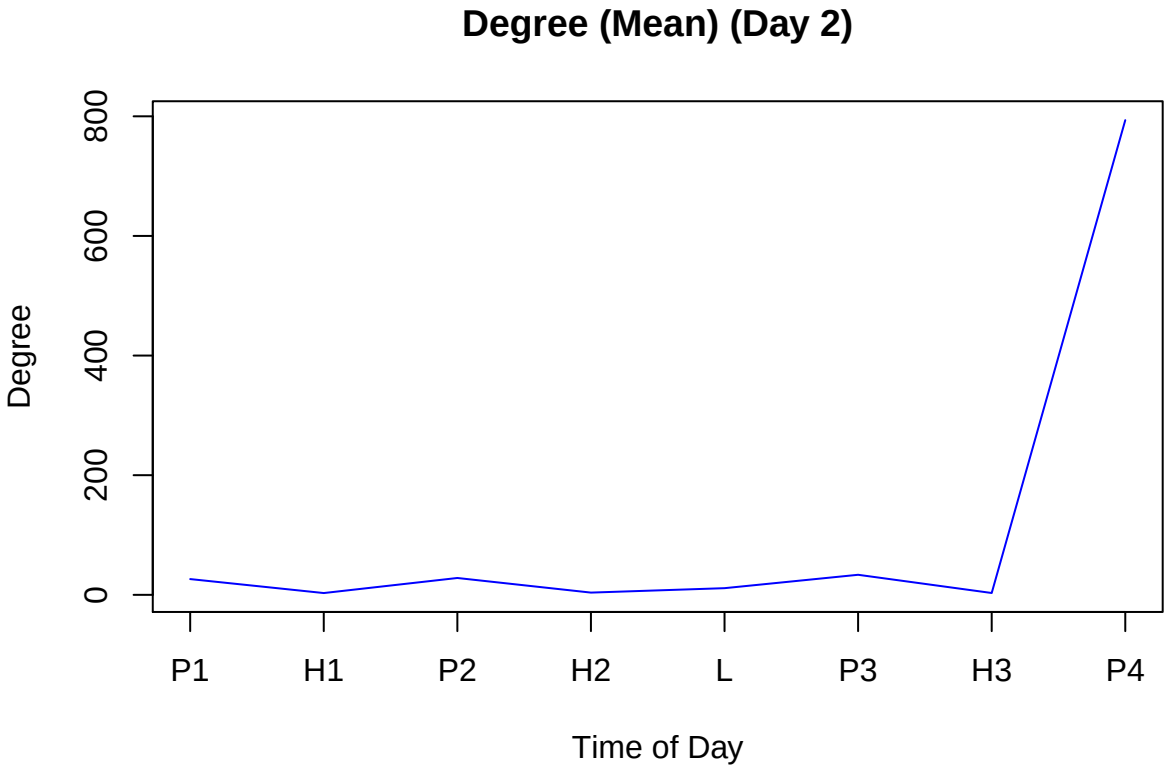
```
##         Measure Min  Q1 Median       Mean  Q3 Max
## 1       All day   2 136    207 216.138947 282 704
## 2  All periods   1  98    154 162.791579 215 500
## 3     Period 1   0  35     61  69.084912  97 307
## 4    Hallway 1   0   1      3   3.347368   5  30
## 5     Period 2   0  11     26  32.202105  46 185
## 6    Hallway 2   0   1      3   3.637895   5  32
## 7        Lunch   0   7     16  18.176842  26  98
## 8     Period 3   0   8     23  29.890526  45 159
## 9    Hallway 3   0   1      2   3.251930   5  20
## 10    Period 4   0   8     24  31.614035  46 182
```



Day 2

```
##         Measure Min  Q1 Median       Mean     Q3  Max
## 1       All day   1 117    208 913.008197 523.50 5223
## 2  All periods   0 102    184 892.109836 481.75 5209
## 3     Period 1   0   5     18  26.311475  39.00  152
## 4    Hallway 1   0   1      2   2.985246   4.00   18
## 5     Period 2   0   7     22  28.167213  40.25  206
## 6    Hallway 2   0   1      3   3.719672   5.00   41
```

```
## 7        Lunch   0   3      8  11.139344  16.00   74
## 8     Period 3   0  13     27  33.509836  48.00  158
## 9    Hallway 3   0   1      2   3.054098   5.00   16
## 10    Period 4   0  19     50 793.554098 344.00 5151
```



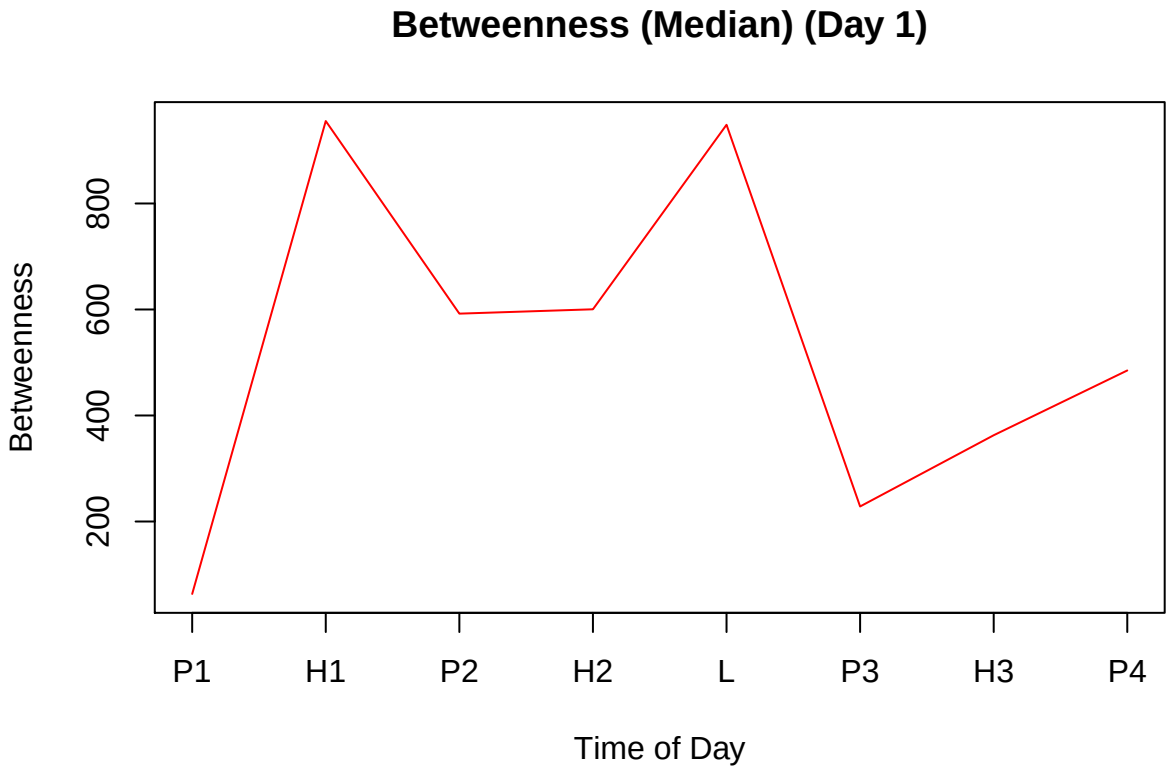
Betweenness

Betweenness represented the nodes that control the "communication flow" in a network. Students with higher betweenness helped connect other students with one another.

Day 1

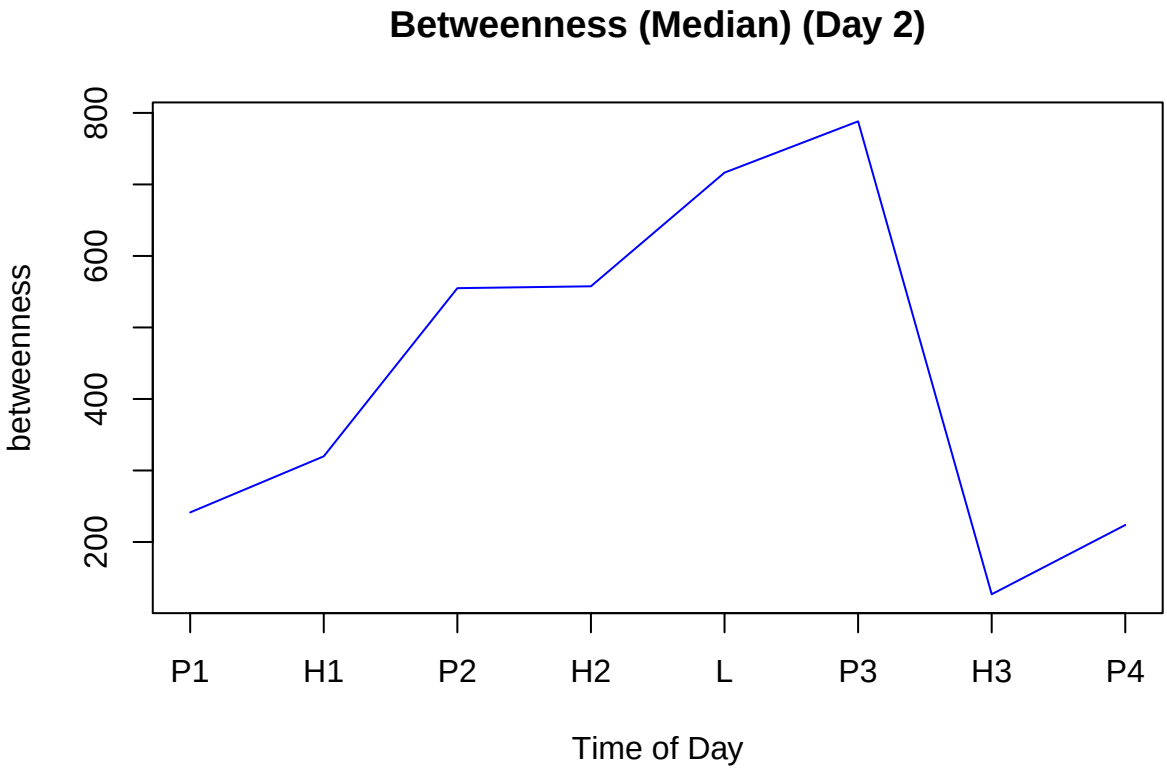
```
##        Measure       Min           Q1    Median      Mean        Q3
## 1      All day 0.1567588 334.93022869 772.89874  956.1979 1354.5604
## 2  All periods 0.0000000 437.95946877 916.32280 1203.0035 1708.0332
## 3     Period 1 0.0000000   1.86578144  63.36503 3461.3235  690.5111
## 4    Hallway 1 0.0000000   0.00000000 955.51833 2447.9186 3315.8083
## 5     Period 2 0.0000000   0.62557498 592.16790 4045.6393 3819.8502
## 6    Hallway 2 0.0000000   0.00000000 600.36704 2119.7972 2719.8638
## 7        Lunch 0.0000000 154.81162615 948.43728 1914.1972 2483.0749
## 8     Period 3 0.0000000   0.01320622 228.33839 4554.3060 2941.0047
## 9    Hallway 3 0.0000000   0.00000000 362.73761 1868.2112 2352.8285
## 10    Period 4 0.0000000   0.08803701 484.93794 3256.3832 3397.2198
##           Max
## 1    6683.899
## 2    9635.527
## 3  220261.761
## 4   39157.746
## 5   97654.775
```

```
## 6   43118.184
## 7   48022.364
## 8  130600.730
## 9   36580.794
## 10  99725.299
```



Day 2

```
##        Measure Min        Q1   Median      Mean        Q3       Max
## 1      All day   0 145.19109 369.3038  698.2984  909.9495  6178.156
## 2  All periods   0 142.07282 380.7294  736.4984  934.5057  6283.603
## 3     Period 1   0   0.00000 241.4009 2539.9492 2621.2555 94858.865
## 4    Hallway 1   0   0.00000 319.7882 1686.9025 2210.1744 32879.639
## 5     Period 2   0   0.00000 554.9565 2893.9148 3587.7324 55082.512
## 6    Hallway 2   0   0.00000 557.5593 1895.7697 2539.1902 26615.949
## 7        Lunch   0   0.00000 716.4939 2312.4434 2747.3453 44071.933
## 8     Period 3   0 152.47484 788.2054 1838.9770 2260.1258 45176.072
## 9    Hallway 3   0   0.00000 126.9584 1456.1705 1898.8175 30874.107
## 10    Period 4   0  26.13226 223.7442 1372.7361 1331.8410 22802.214
```

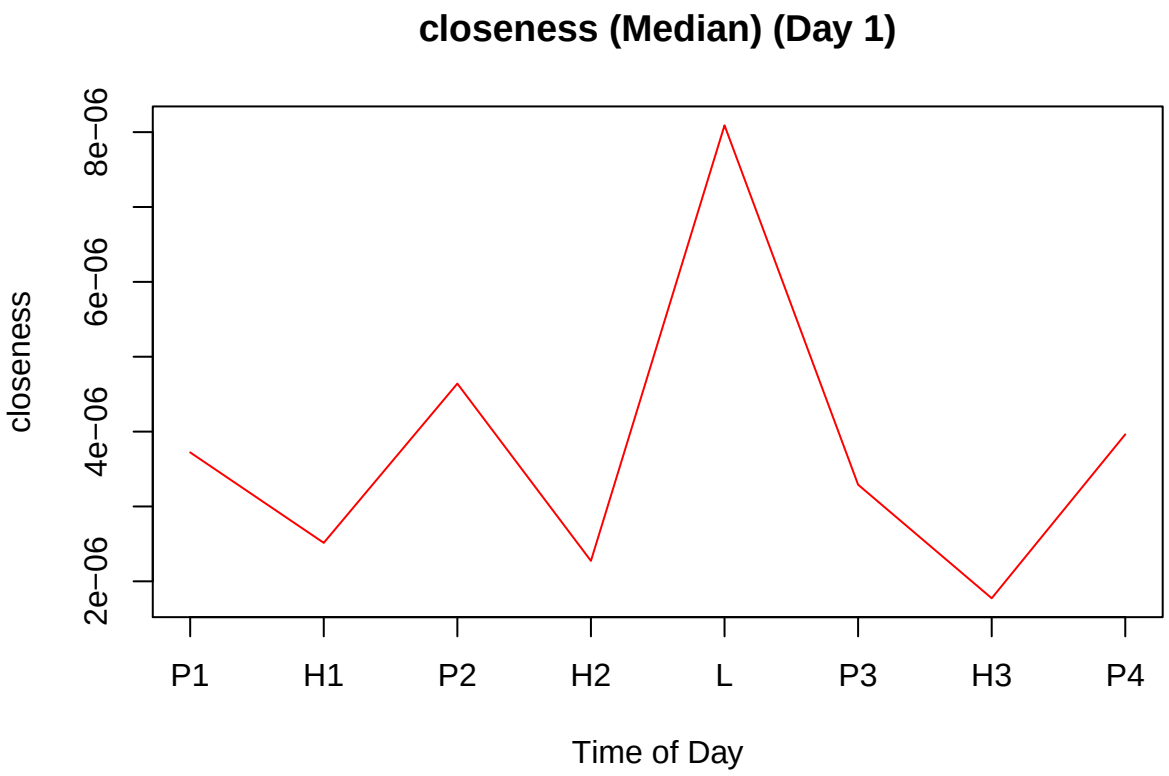


Closeness

Closeness measured how close a node was to all other nodes in the network.

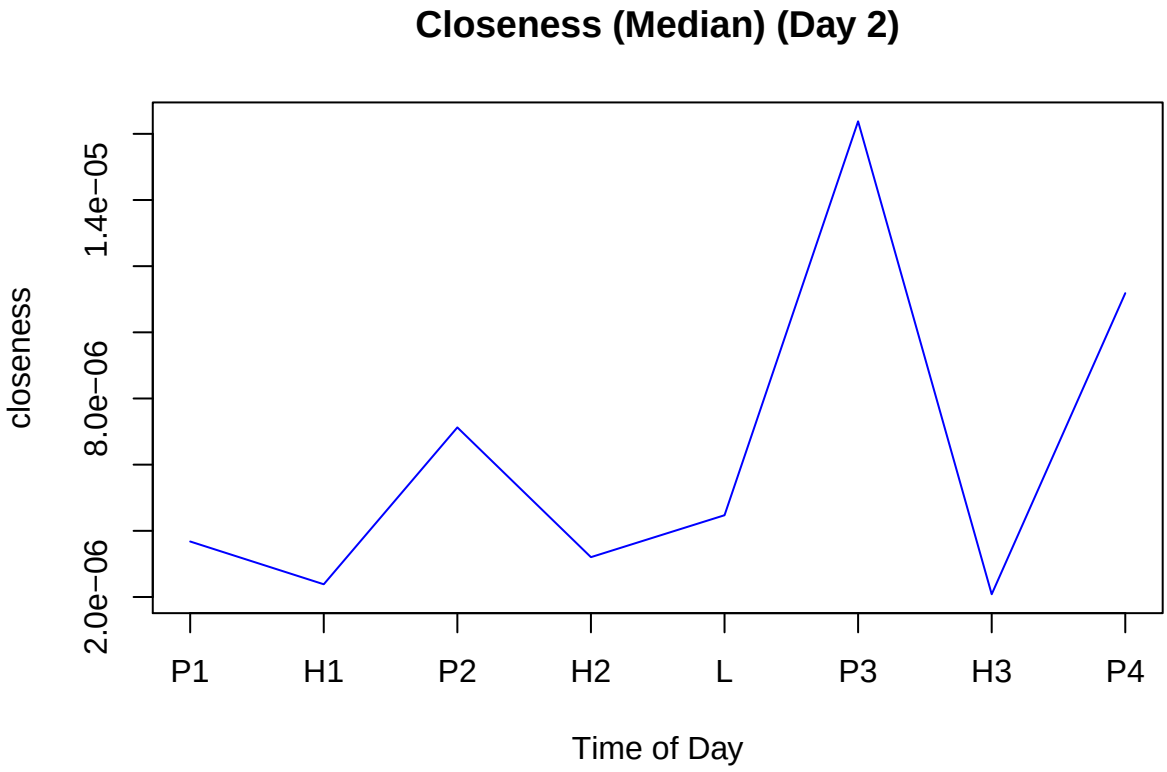
Day 1

```
##        Measure          Min           Q1       Median         Mean
## 1      All day 2.134016e-04 2.866972e-04 3.020236e-04 3.011528e-04
## 2  All periods 1.476233e-04 2.535497e-04 2.629503e-04 2.619763e-04
## 3     Period 1 4.928050e-07 3.702127e-06 3.722163e-06 3.312085e-06
## 4    Hallway 1 4.928050e-07 2.504182e-06 2.514199e-06 2.125963e-06
## 5     Period 2 4.928050e-07 4.610122e-06 4.641082e-06 4.222076e-06
## 6    Hallway 2 4.928050e-07 2.264559e-06 2.273203e-06 1.894226e-06
## 7        Lunch 4.928050e-07 8.053540e-06 8.090615e-06 7.643305e-06
## 8     Period 3 4.928050e-07 3.264667e-06 3.290903e-06 2.887783e-06
## 9    Hallway 3 4.928050e-07 4.931511e-07 1.774075e-06 1.423272e-06
## 10    Period 4 4.928050e-07 3.943482e-06 3.963221e-06 3.546797e-06
##              Q3          Max
## 1  3.165559e-04 3.526093e-04
## 2  2.718130e-04 3.082614e-04
## 3  3.736041e-06 3.765386e-06
## 4  2.518892e-06 2.526899e-06
## 5  4.661440e-06 4.705882e-06
## 6  2.277074e-06 2.285046e-06
## 7  8.115500e-06 8.179825e-06
## 8  3.303263e-06 3.326835e-06
## 9  1.776483e-06 1.780877e-06
## 10 3.976649e-06 4.004934e-06
```



Day 2

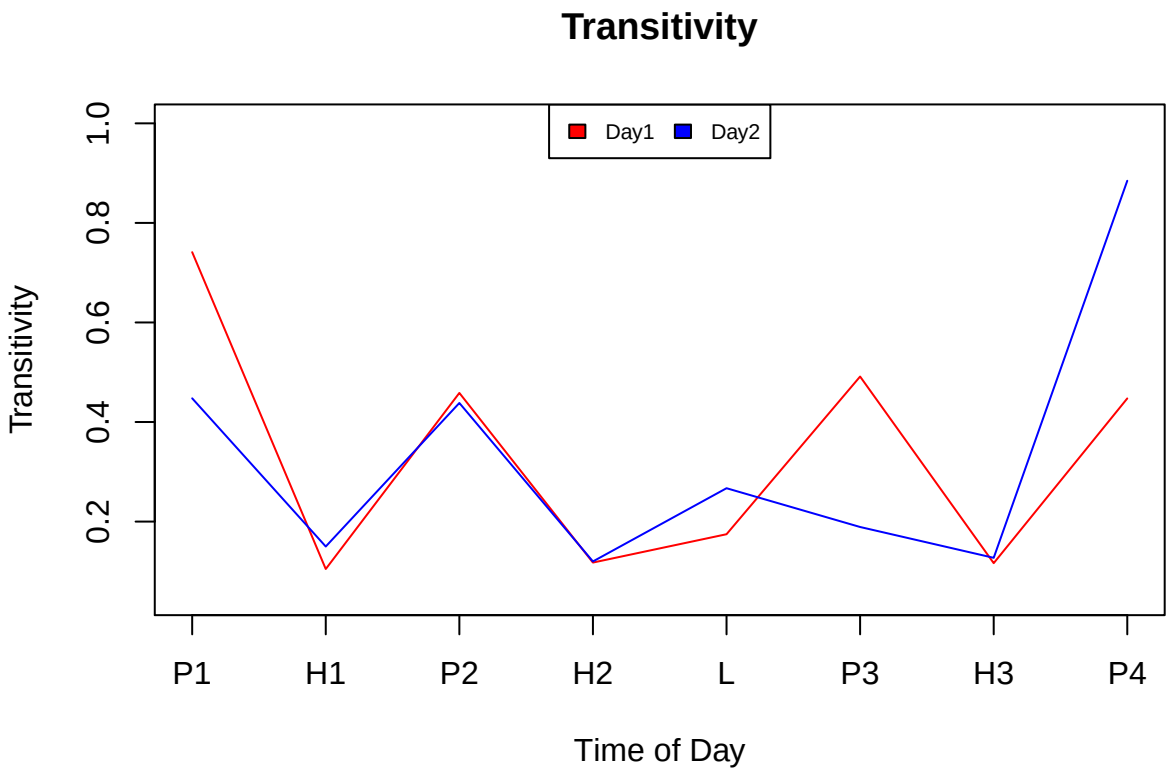
```
##        Measure          Min           Q1       Median         Mean
## 1      All day 2.391772e-04 3.524850e-04 3.757280e-04 3.886689e-04
## 2  All periods 6.724136e-07 2.403846e-04 2.510040e-04 2.577183e-04
## 3     Period 1 6.724136e-07 3.654420e-06 3.677174e-06 3.143374e-06
## 4    Hallway 1 6.724136e-07 6.729652e-07 2.384381e-06 1.909823e-06
## 5     Period 2 6.724136e-07 7.073874e-06 7.125679e-06 6.544543e-06
## 6    Hallway 2 6.724136e-07 3.188793e-06 3.204353e-06 2.684412e-06
## 7        Lunch 6.724136e-07 4.451265e-06 4.471292e-06 3.917690e-06
## 8     Period 3 6.724136e-07 1.626076e-05 1.637774e-05 1.577242e-05
## 9    Hallway 3 6.724136e-07 6.729652e-07 2.083062e-06 1.634518e-06
## 10    Period 4 6.724136e-07 1.106960e-05 1.118374e-05 1.057664e-05
##              Q3          Max
## 1  4.314529e-04 4.791567e-04
## 2  2.797398e-04 2.998501e-04
## 3  3.686133e-06 3.709446e-06
## 4  2.388104e-06 2.394768e-06
## 5  7.156506e-06 7.235419e-06
## 6  3.210832e-06 3.221847e-06
## 7  4.482948e-06 4.510335e-06
## 8  1.647202e-05 1.669533e-05
## 9  2.086366e-06 2.090594e-06
## 10 1.130135e-05 1.135525e-05
```



Transitivity

Transitivity measured the likelihood nodes will cluster together.

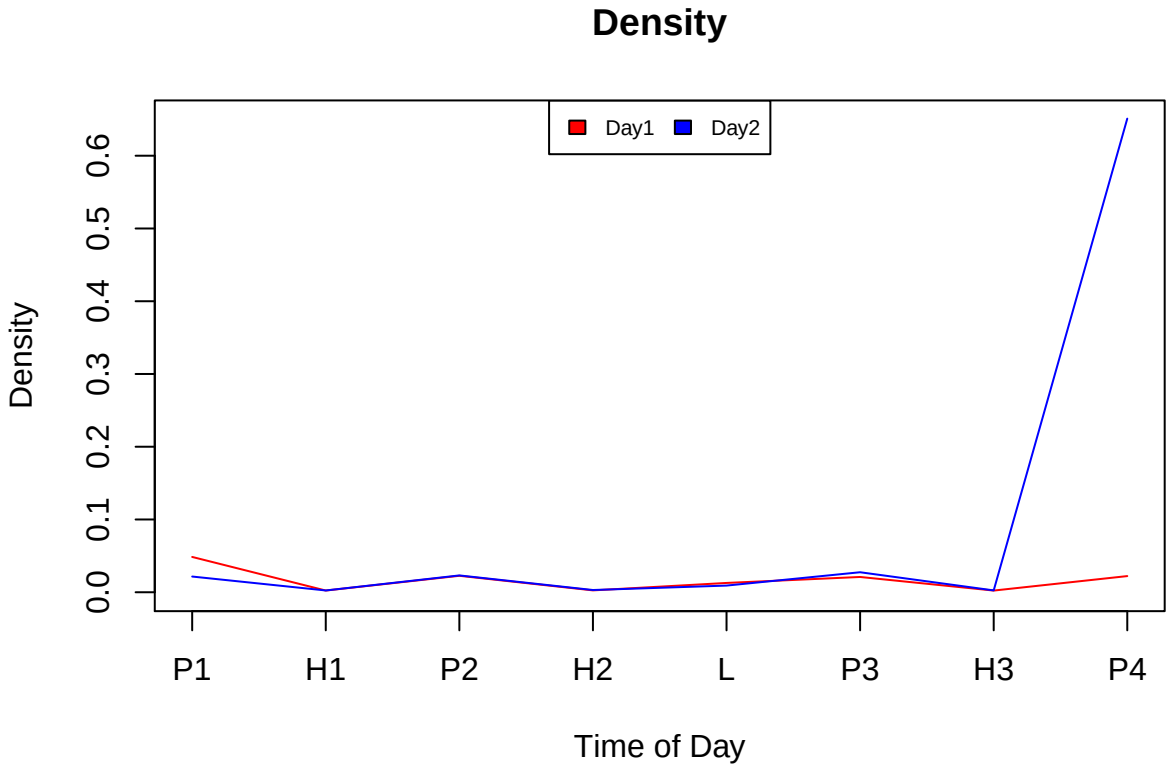
```
##        Measure      Day1      Day2
## 1      All day 0.1823022 0.7506676
## 2  All periods 0.2978069 0.7779085
## 3     Period 1 0.7412191 0.4475851
## 4    Hallway 1 0.1046884 0.1498767
## 5     Period 2 0.4584243 0.4382355
## 6    Hallway 2 0.1176294 0.1198721
## 7        Lunch 0.1746072 0.2670097
## 8     Period 3 0.4913340 0.1891207
## 9    Hallway 3 0.1164544 0.1271959
## 10    Period 4 0.4473970 0.8846711
```



Density

Density was the proportion of actual edges divided by potential edges.

```
##        Measure        Day1        Day2
## 1      All day 0.151782969 0.748981293
## 2  All periods 0.114319929 0.731837437
## 3     Period 1 0.048514686 0.021584475
## 4    Hallway 1 0.002350680 0.002448930
## 5     Period 2 0.022613838 0.023106820
## 6    Hallway 2 0.002554701 0.003051413
## 7        Lunch 0.012764636 0.009138100
## 8     Period 3 0.020990538 0.027489611
## 9    Hallway 3 0.002283659 0.002505413
## 10    Period 4 0.022200867 0.650987776
```

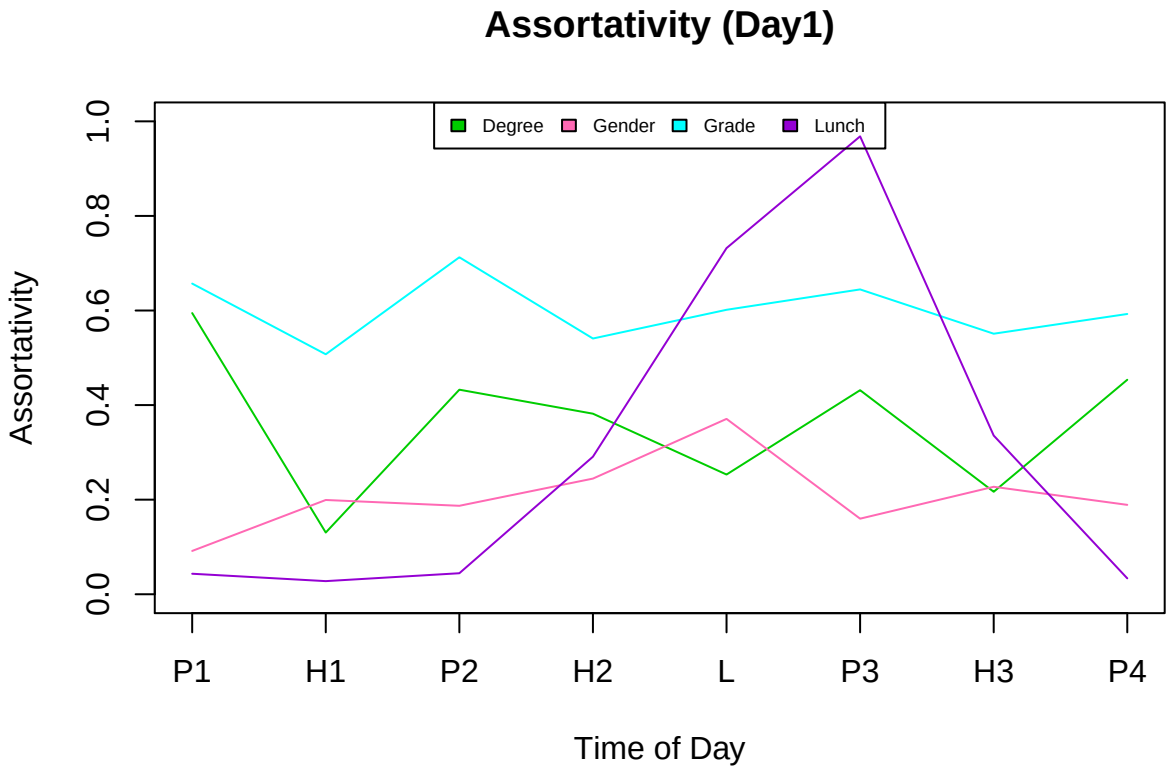


Assortativity

Assortativity measured the probability that students interacted with other students with similar characteristics. The study evaluated four characteristics: gender, grade, lunch, and degree, and calculated the assortativity. Grade and Gender were coded as "GenderCat" and "GradeCat" to match other files.

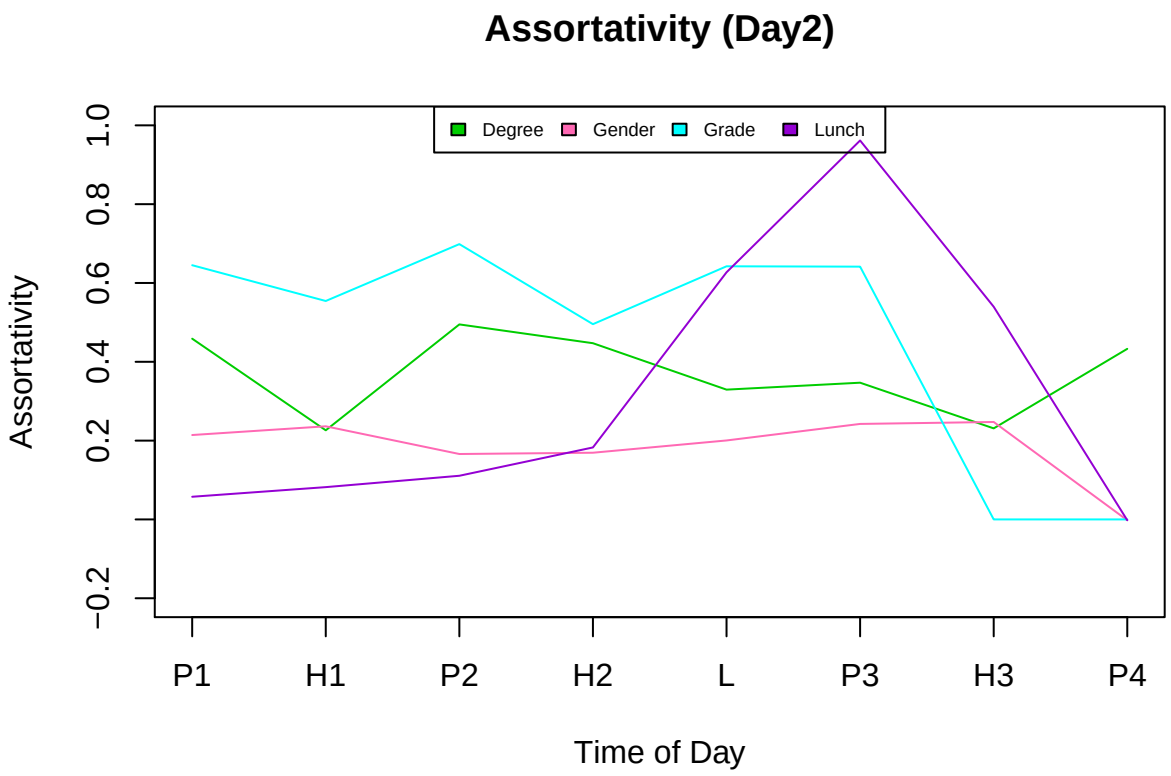
Day 1

```
##        Measure    Degree  GenderCat  GradeCat      Lunch
## 1      All day 0.1729348 0.18532409 0.6176091 0.24153951
## 2  All periods 0.2143047 0.14201952 0.6555558 0.20689575
## 3     Period 1 0.5945900 0.09155421 0.6569461 0.04336572
## 4    Hallway 1 0.1304607 0.19934872 0.5074168 0.02772307
## 5     Period 2 0.4325414 0.18705206 0.7125158 0.04444116
## 6    Hallway 2 0.3817808 0.24454924 0.5407445 0.29084927
## 7        Lunch 0.2531446 0.37082585 0.6014776 0.73191453
## 8     Period 3 0.4314996 0.15979813 0.6446122 0.96825876
## 9    Hallway 3 0.2166636 0.22722294 0.5509142 0.33554356
## 10    Period 4 0.4535261 0.18897755 0.5926358 0.03361289
```

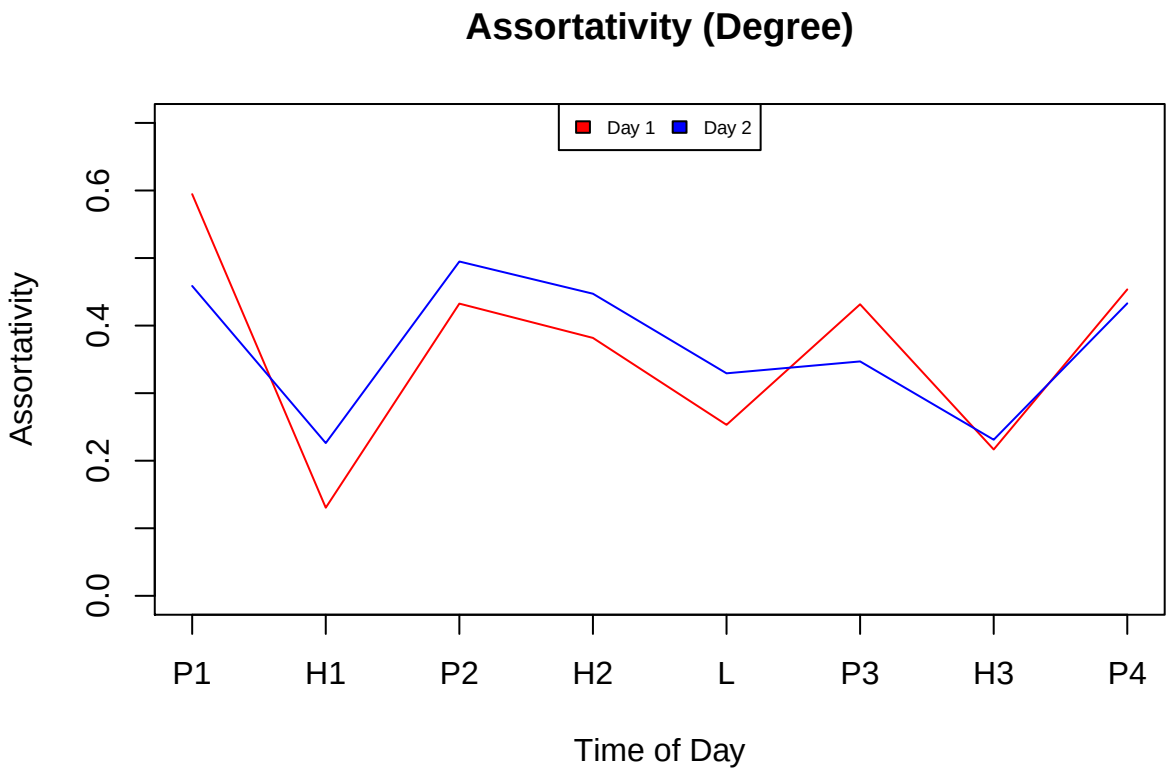


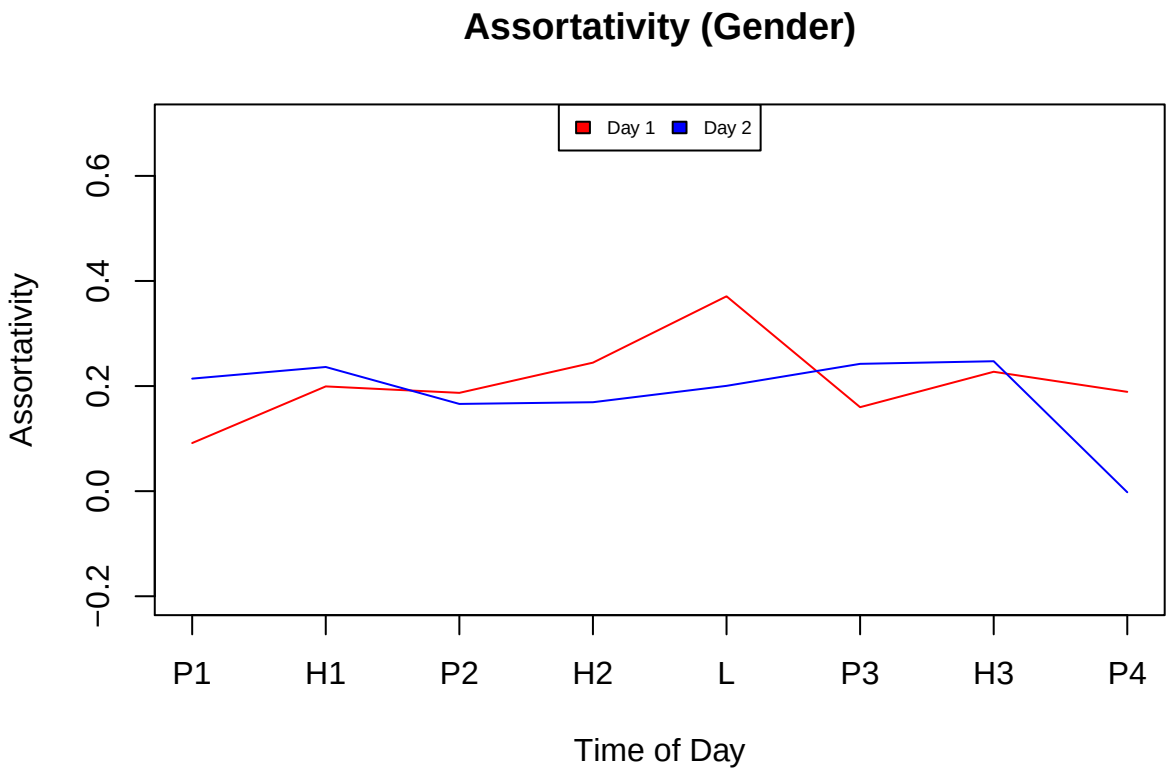
Day 2

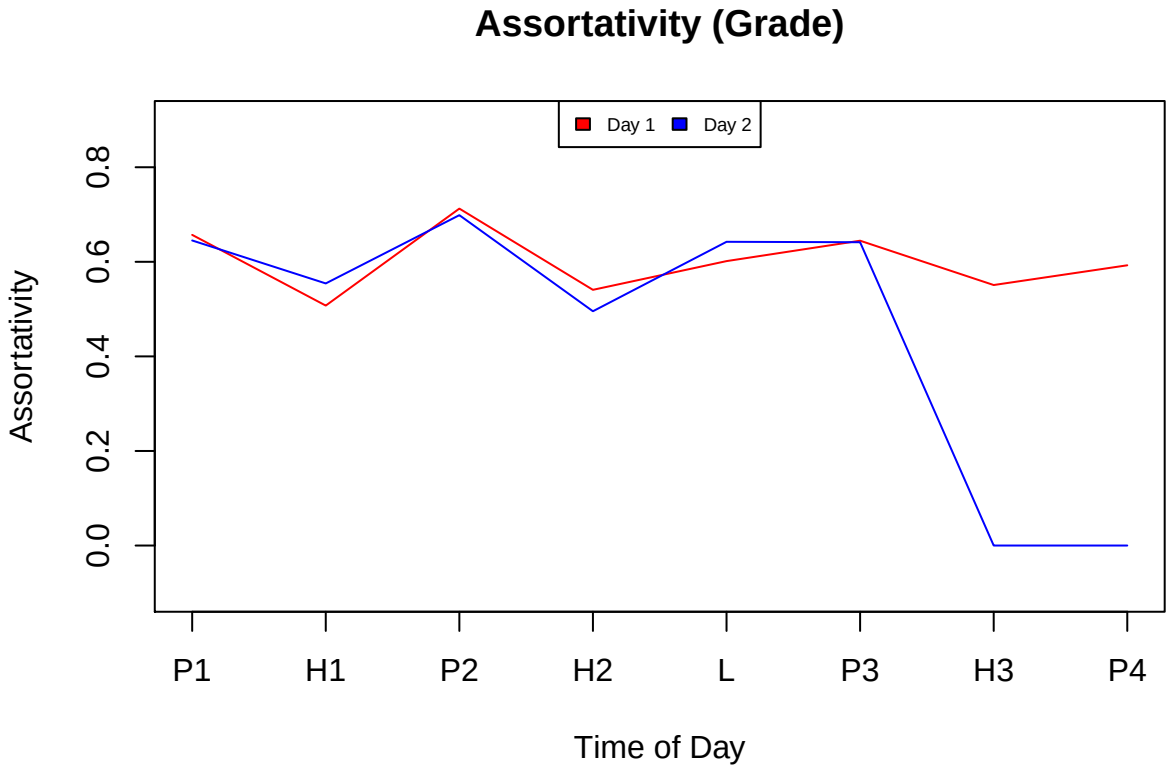
```
##         Measure    Degree   GenderCat   GradeCat        Lunch
## 1       All day 0.5618487  0.02708553 0.09573177  0.048471248
## 2  All periods 0.5514066  0.02267020 0.08264291  0.039003851
## 3     Period 1 0.4586588  0.21416905 0.64510699  0.057504029
## 4    Hallway 1 0.2261451  0.23631466 0.55427274  0.081951891
## 5     Period 2 0.4948827  0.16602239 0.69864308  0.110788210
## 6    Hallway 2 0.4471911  0.16923223 0.49546541  0.182620132
## 7        Lunch 0.3293667  0.20039163 0.64233551  0.627094628
## 8     Period 3 0.3469509  0.24230235 0.64143490  0.961614982
## 9    Hallway 3 0.2310550  0.24723797 0.00000000  0.539674517
## 10    Period 4 0.4328890 -0.00210218 0.00000000 -0.002105876
```

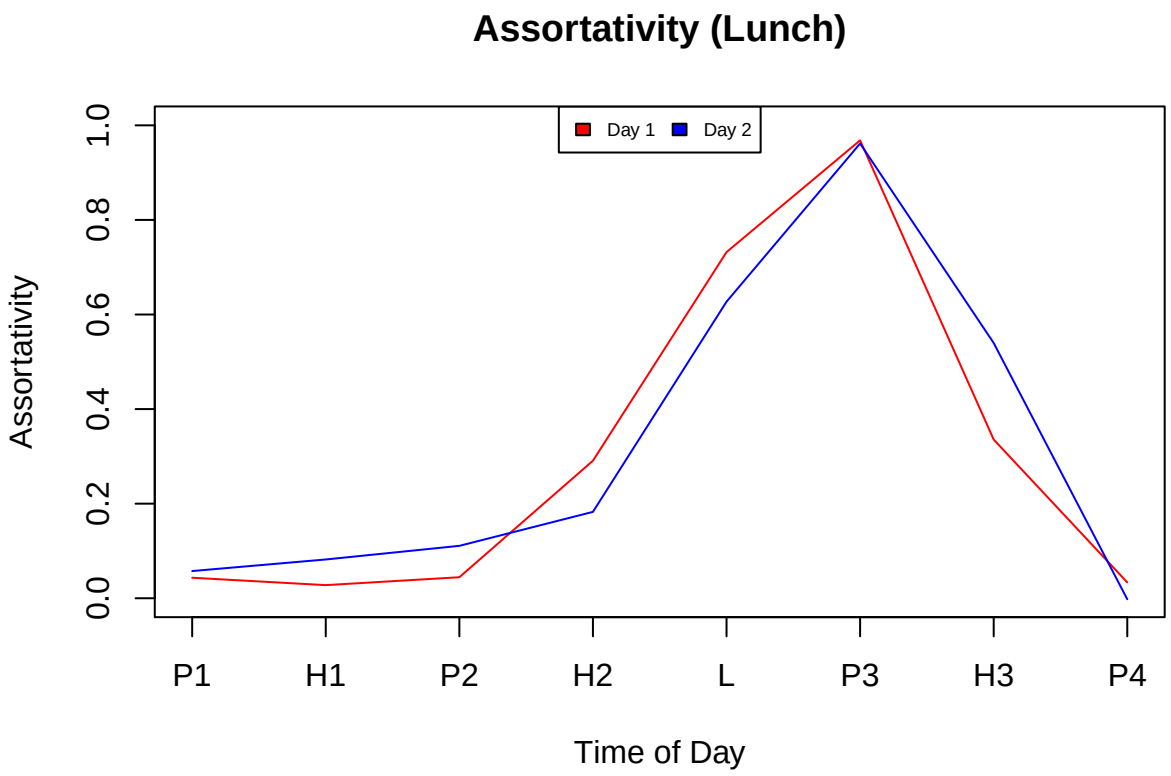


Comparing each characteristic between days:




Assortativity (Gender)
Day 1
Day 2
Assortativity
−0.2
0.0
0.2
0.4
0.6
P1
H1
P2
H2
L
P3
H3
P4
Time of Day


Assortativity (Grade)
Day 1
Day 2
Assortativity
0.0
0.2
0.4
0.6
0.8
P1
H1
P2
H2
L
P3
H3
P4
Time of Day


Assortativity (Lunch)
Day 1
Day 2
Assortativity
0.0
0.2
0.4
0.6
0.8
1.0
P1
H1
P2
H2
L
P3
H3
P4
Time of Day