How Are Teen Social Circles Transformed in Crisis? Exploring the Impact of Influential Peers on High School Students' Networks During the COVID-19 Pandemic

Chi-Shiun Tsai[0009−0005−7311−3107]

Carnegie Mellon University, Pittsburgh PA 15213, USA
chishiut@andrew.cmu.edu

Abstract. How are teen social circles transformed in crisis? This study explores the impact of influential peers on high school students' networks during the COVID-19 pandemic, especially during school closures. While COVID-19 cases in Taiwan had remained low since the pandemic began, high schools in Taiwan closed in May 2022 due to a sudden surge in COVID-19 cases. By constructing networks from survey and Instagram data collected from March 2022 to June 2022 with 57 students in Taiwan, the results indicate that these influential peers play a crucial role in the structure of the network and its efficiency in spreading and connecting information. In addition, the online likes-shared network outperforms other networks in terms of their correlations with the offline friendship network. These findings highlight the importance of integrating insights from both offline and online networks to inform educational policies aimed at enhancing student engagement and maintaining social connections during school closures.

Keywords: COVID-19 · Friendship networks · Instagram · Influential peers

1 Introduction

During public health emergencies, the social infrastructure of communities is put to the test. People reach out to others in their networks for support, which is essential for information gain and well-being [3, 6]. During the COVID-19 pandemic, people relied on online platforms to interact with others due to limited in-person interaction. The influence of this pivot to online communication channels was not uniform across demographics. High school students are particularly vulnerable to the impacts of the pandemic due to the abrupt shift to remote learning, limited opportunities for in-person interactions, and the unique developmental challenges and social pressures they face during this transitional life stage [4, 8]. In the absence of teacher participation in their online networks, high school students rely heavily on influential peers, such as "key players" and "opinion leaders," to gain knowledge and information beyond the classroom setting

[11]. These influential peers within their networks play a critical role in shaping not only the academic but also the social structures of their cohorts.

While the number of daily COVID-19 cases in Taiwan had been low since the pandemic began, the government closed high schools on May 19, 2022 (from May to June 2022) due to a sudden surge in COVID-19 daily cases, resulting in a switch to online learning [9]. This paper aims to explore the impact of influential peers on high school students' networks during school closures, and to understand how these influential peers can be leveraged to support students during public health crisis.

2 Related Work

School closures influenced daily in-person interactions that are crucial to adolescent social networks. A study highlights the disruption of students' networks and how the lack of physical presence within educational settings led to a significant increase in mental health issues among students [7]. The importance of physical activities and socialization in providing social support is also emphasized by another study exploring the impact of school closures on adolescents [5]. In addition, a study explores how these closures have influenced the development of social emotional skills, as schools often serve as primary environments for social learning during adolescence [10].

As in-person interactions are limited during school closures, online platform became more important for high school students to maintain social connections. Visual-based social media platforms, such as Instagram, allowed students to maintain peer connections through shared experiences [2]. However, a study shows that while Instagram provides a valuable space for interaction, it can also lead to a decline in health-related quality of life [12].

Most studies focus on either the online interactions or the offline relationships. This study aims to capture the dynamics of offline and online interactions to understand the relationships between high school students during school closures.

3 Methods

3.1 Data

This study uses data collected from March 2022 to June 2022. The Institutional Review Board on Humanities and Social Science Research of Academia Sinica in Taiwan approved the data collection process (AS-IRB-HS07-111081) [13]. Only the classes with a response rate greater than 90% are included in this research to ensure that the majority of the network is represented. In total, 57 students from multiple high schools in Taiwan completed the survey and provided their Instagram data. The former includes demographic information, socioecnomic status, and academic performance, and the latter includes following (followers)

and posts (comments) liked. Although some students did not provide their Instagram data, this research only includes students who completed the survey and provided their Instagram data. To anonymize the data, each student was assigned a network ID based on their school number and the student number randomly generated, rather than using their Instagram account name.

The survey questions took between 30 and 40 minutes to complete. The time range of the first wave is from March 15 to April 15, 2022, and the second wave is from June 1 to June 15, 2022. To ensure the validity of the survey, participants were repeatedly asked the same questions during each wave and were allowed to complete the survey at any given time within the specified date range. The measured variables include demographic characteristics, socioeconomic status, academic performance, and friendship network (students indicated their friends in the class by answering a yes-no question for each classmate).

The Instagram data provided by the students includes the followers and following folder and the likes folder. The former indicates the time when one starts following another student on Instagram, and the latter includes the time when one likes another student's posts or comments.

3.2 Network Construction

The networks were built from the responses to the survey and the Instagram data provided by the students. Nodesets include students and Instagram content, such as posts and comments. A single network per type is constructed for all students. There are two main types of networks: offline and online networks. The former include the friendship network constructed from the question asking students to identify their friends in class, while the latter include following, likes, and shared posts (comments) networks that are built from the Instagram json files. The following sections provide details of each network, such as what the nodes represent and how the links are defined. All network analyses were performed using ORA, a tool for dynamic network analysis [1].

Node Attributes 68.42% of the students are female, and 61.40% of the students identify their family income level as average. The average admission grade is 1.95 with a standard deviation of 0.29.

Friendship Network The friendship network represents offline friendships among students, which is constructed on the basis of the survey question asking students to indicate their friends in class. The nodes represent the students, and the edge between two nodes exists if both students consider one another as friends. The edge is binary, indicating whether both students consider each other friends.

Following Network The nodes represent the Instagram users, and the directed links represent the following connections between them (A follows B). From pre-

to post-period, the number of links decreases significantly from 25 to 12, indicating that students became less active in forming new following relationships. This could be attributed to changes in social behavior due to school closures.

Likes Network The likes network is constructed based on the likes files. The nodes represent Instagram users (labeled with student number) and the posts/comments liked by the users (labeled with URL), and direct links indicate the user liking the comments or posts of another user. From pre- to post-period, the number of links increases from 33 to 49, suggesting that students like each other's posts and comments more during school closures.

Likes Network - Shared Post/Comment (Weighted/Binary) The shared post/comment network is created by folding the likes network. The nodes represent Instagram users, and the weighted links indicated the number of common posts or comments liked by the users. We also created another version of this network with binary links, indicating whether two users share common posts or comments. In particular, the number of links increases significantly from 72 to 128, indicating that there are more shared posts and comments among students during school closures.

Changes in Offline Friendships and Online Interactions Table 1 shows the changes in offline friendships and online interactions. The category is constructed from the friendship network, and the number of likes posts and comments comes from the likes network. Across the four categories, the number of liked posts and comments increases. For example, for those who were friends and stayed friends, there is a slight increase in the number of liked posts and comments. This trend suggests that despite any changes in offline friendships, online interactions generally intensified during school closures. Interestingly, those who were not friends and stayed not friends also show an increase in the number of liked posts and comments.

Table 1. Changes in Offline Friendships and Online Interactions

Category	Period	Liked Posts and Comments # (%)
Friends and stayed friends	Pre	10 (14.08%)
	Post	11 (15.49%)
Friends and stopped being friends	Pre	2 (2.82%)
	Post	4 (5.63%)
Not friends and became friends	Pre	0 (0.00%)
	Post	2 (2.82%)
Not friends and stayed not friends	Pre	17 (23.94%)
	Post	25 (35.21%)

3.3 Identify Key Actors and Examine Immediate Impact

To identify influential peers and check whether influential peers change after school closure, we ran the Key Entities Report in ORA [1]. In addition, we ran the Immediate Impact Report after removing the top-ranked students to examine the impact.

3.4 Compare Networks and Components in Each Network

We compared the number of components and the size of the components to check if there was an increase in fragmentation or consolidation within the networks, which is crucial to understanding how the structure of interactions evolved during school closures.

3.5 Quadratic Assignment Procedure/Multiple Regression Quadratic Assignment Procedure (QAP/MRQAP) Analysis

To examine the correlation between different types of networks, we ran a QAP/MRQAP analysis in ORA on various combinations. Table 2 represents the types of model comparisons. The first six models examine the impact of school closure on different types of networks, the first six models explore the correlation between different networks in each time period, the other six models focus on the correlation between friendship network and the other networks for both pre- and post-period, the following four models examine the relationship between friendship network, following, and likes networks, and the last four models focus on finding the potential impact of online networks in pre-period on offline friendships in post-period.

4 Results

4.1 Key Actors

Table 3 shows the results of the Key Entities Report. In the friendship networks, students 3909 and 2628 are both top-ranked agents in both periods. In the following networks, the top-ranked agents change more significantly. As for the likes networks, student 2608 is the only one among the top-ranked agents in both time periods. Student 2522 is in both the friendship network and the shared post/comment network.

4.2 Immediate Impact

Table 4 shows the immediate impact in the network-level measures after removing the top three students from each network. The results show that these students play an important role in the structure of the network and its efficiency in the spread and connectivity of information.

Table 2. Models

Model	Network	Period
Model 1	Friendship	Pre vs. Post
Model 2	Following	Pre vs. Post
Model 3	Likes	Pre vs. Post
Model 4	Likes - Shared	Pre vs. Post
Model 5	Likes (binary)	Pre vs. Post
Model 6	Likes - Shared (binary)	Pre vs. Post
Model 7	Friendship vs. Following	Pre
Model 8	Friendship vs. Following	Post
Model 9	Friendship vs. Likes - Shared	Pre
Model 10	Friendship vs. Likes - Shared	Post
Model 11	Friendship vs. Likes - Shared (binary)	Pre
Model 12	Friendship vs. Likes - Shared (binary)	Post
Model 13	Friendship / Following / Likes - Shared	Pre
Model 14	Friendship / Following / Likes - Shared	Post
Model 15	Friendship / Following / Likes - Shared (binary)	Pre
Model 16	Friendship / Following / Likes - Shared (binary)	Post
Model 17	Friendship / Following / Likes - Shared	Pre vs. Post
Model 18	Friendship / Following / Likes - Shared (binary)	Pre vs. Post
Model 19	Friendship / Friendship / Following / Likes - Shared	Pre vs. Post
Model 20	Friendship / Friendship / Following / Likes - Shared (binary)	Pre vs. Post

Table 3. Key Entities Report

Data	Network	Period	Overall Top-Ranked Agent
Survey	Friendship	Pre	3909, 3926, 2522, 2615, 2628
		Post	3916, 2610, 2628, 3930, 3909
Instagram	Following	Pre	3932, 3909, 3911, 3931, 3915
		Post	3927, 3913, 2524, 3926, 2507
	Likes	Pre	3927, 2519, 2608, 2616, 2623
		Post	3918, 2522, 3926, 2514, 2608
	Likes - Shared	Pre	2514, 2522, 2528, 2519, 2523
		Post	3913, 3915, 2608, 3916, 3918

Table 4. Immediate Impact

Network	Period	Largest Decrease	Largest Increase
Friendship	Pre	Diffusion (-23.44%)	Avg. Communication Speed (+27.11%)
	Post	Diffusion (-10.56%)	Number of Isolated Agents (+20%)
Following	Pre	Clustering Coefficient (-100%)	Avg. Communication Speed (+229.51%)
	Post	Diffusion (-59.40%)	Avg. Communication Speed (+64.34%)
Likes	Pre	Overall Complexity (-10.49%)	
	Post	Overall Complexity (-10.49%)	
Likes - Shared	Pre	Clustering Coefficient (-5.33%)	Avg. Communication Speed (+25%)
	Post	Characteristic Path Length (-8.47%)	Avg. Communication Speed (+9.52%)

4.3 Components in Each Network

Table 5 shows the number of components in each network. For the friendship network, the number of isolates remains the same, but the number of triads increases from zero to one. For the following network, the number of larger components increases from one to two. For the like network, the number of dyads decreases from two to one. In the shared post/comment network, the number of isolates decreases from three to one, and the number of larger components increases from two to three.

Table 5. Number of Components in Each Network

Network	Period	Isolates	Dyads	Triads	Larger	Larger sizes
Friends	Pre	5	0	0	5	Min: 4, Max: 12, Mean: 9, Std: 3.35
	Post	5	0	1	4	Min: 6, Max: 14, Mean: 10.5, Std: 2.96
Following	Pre	0	0	0	1	Min: 13, Max: 13, Mean: 13, Std: 0
	Post	0	0	0	2	Min: 4, Max: 7, Mean: 5.5, Std: 1.5
Like	Pre	0	2	0	3	Min: 4, Max: 11, Mean: 8.67, Std: 3.3
	Post	0	1	0	3	Min: 10, Max: 16, Mean: 12.33, Std: 2.62
Like - Shared	Pre	3	0	0	2	Min: 6, Max: 7, Mean: 6.5, Std: 0.5
	Post	1	0	0	3	Min: 6, Max: 8, Mean: 7, Std: 0.82

4.4 QAP/MRQAP Analysis

Table 6 presents the results of the QAP/MRQAP analysis. Based on the first six models, the likes network in the post period is negatively correlated with that in the pre period, while the likes-shared network in the post period is positively correlated with that in the pre period. According to the following six models, the likes-shared network is positively correlated with the friendship network in both periods. The next four models show that the likes-shared network has a stronger correlation with the friendship network than the following network based on statistical significance. In particular, the coefficient of the binary liked-shared network is higher than that of the original liked-shared network. The last four models demonstrate that the liked-shared network in the pre-period is positively correlated with the friendship network in the post-period, providing a compelling case for the use of an online interaction network in detecting changes in an offline friendship network.

5 Limitations and Future Work

Since this research is based on the survey responses and the Instagram data provided by high school students, there are some limitations. The friendship network is constructed based on the friends each student identifies in class. Students might not be able to recall all their friends or misidentify all classmates as friends, which could lead to incorrect representations of the friendship network. In addition, information on offline interactions is limited. The offline aspect of relationships is built on the survey data only. Therefore, we did not have the full picture of high school students' offline interactions.

To address these issues, future research could explore utilizing wearable devices to record offline interactions between students. In addition, multiple social media platforms could diversify the sources of online interactions.

6 Conclusion

This research explores how the social circles of high school students changed during the COVID-19 pandemic, particularly during school closures. The results show that although individuals regarded as influential peers may change, their role in maintaining social structure remains consistent. In addition, online interactions increase during school closures regardless of students' friendship status. The likes-shared network outperforms other types of network in terms of their correlations with the friendship network, which indicates that online interactions can provide insight into offline friendships. It is essential for high school students to maintain communication during the pandemic to maintain their friendships.

The findings of this study provide information for educational policies. Policies that promote the organizing of virtual events and online group activities can be effective in this regard. Moreover, leveraging peer influence for engagement is critical when in-person interactions are limited. Empowering these key players

Table 6. Model Results

Model	Dependent network	Independent network(s)	Coefficients	Std. Errors	Sig.Y-Perm
1	Friendship - Post	Friendship - Pre	0.496	0.022	**0**
2	Following - Post	Following - Pre	-0.037	0.040	1
3	Likes - Post	Likes - Pre	-0.068	0.047	0.851
4	Likes - Shared - Post	Likes - Shared - Pre	0.519	0.066	**0**
5	Likes (binary) - Post	Likes (binary) - Pre	- 0.040	0.045	0.746
6	Likes - Shared (binary) - Post	Likes - Shared (binary) - Pre	0.871	0.056	**0**
7	Friendship - Pre	Following - Pre	0.200	0.045	**0.018**
8	Friendship - Post	Following - Post	0.009	0.055	0.410
9	Friendship - Pre	Likes - Shared - Pre	0.128	0.036	**0.009**
10	Friendship - Post	Likes - Shared - Post	0.198	0.026	**0**
11	Friendship - Pre	Likes - Shared (binary) - Pre	0.340	0.064	**0.001**
12	Friendship - Post	Likes - Shared (binary) - Post	0.313	0.043	**0**
13	Friendship - Pre	Likes - Shared - Pre	0.130	0.025	**0.009**
		Following - Pre	0.203	0.044	**0.022**
14	Friendship - Post	Likes - Shared - Post	0.199	0.018	**0**
		Following - Post	-0.033	0.054	0.436
15	Friendship - Pre	Likes - Shared (binary) - Pre	0.344	0.045	**0**
		Following - Pre	0.206	0.044	**0.012**
16	Friendship - Post	Likes - Shared (binary) - Post	0.314	0.031	**0**
		Following - Post	-0.031	0.054	0.554
17	Friendship - Post	Likes - Shared - Pre	0.169	0.023	**0.003**
		Following - Pre	0.112	0.040	0.052
18	Friendship - Post	Likes - Shared (binary) - Pre	0.436	0.040	**0**
		Following - Pre	0.115	0.039	**0.036**
19	Friendship - Post	Friendship - Pre	0.487	0.015	**0**
		Likes - Shared - Pre	0.106	0.019	**0.013**
		Following - Pre	0.013	0.034	0.296
20	Friendship - Post	Friendship - Pre	0.477	0.015	**0**
		Likes - Shared (binary) - Pre	0.272	0.034	**0**
		Following - Pre	0.017	0.034	0.249

to lead virtual study groups can further enhance student engagement and help maintain social circles.

References

1. Carley, K.M.: ORA: A toolkit for dynamic network analysis and visualization. (2014)
2. Dennen, V.P., Rutledge, S.A., Bagdy, L.M.: (dis) connected: The role of social networking sites in the high school setting. American Journal of Education **127**(1), 107–136 (2020)
3. Ellis, W.E., Dumas, T.M., Forbes, L.M.: Physically isolated but socially connected: Psychological adjustment and stress among adolescents during the initial COVID-19 crisis. Canadian Journal of Behavioural Science/Revue canadienne des sciences du comportement **52**(3), 177 (2020)
4. Espinoza, G., Hernandez, H.L.: Adolescent loneliness, stress and depressive symptoms during the COVID-19 pandemic: The protective role of friends. Infant and Child Development **31**(3), e2305 (2022)
5. Esposito, S., Giannitto, N., Squarcia, A., Neglia, C., Argentiero, A., Minichetti, P., Cotugno, N., Principi, N.: Development of psychological problems among adolescents during school closures because of the COVID-19 lockdown phase in Italy: A cross-sectional survey. Frontiers in Pediatrics **8**, 628072 (2021)
6. Gadassi Polack, R., Sened, H., Aubé, S., Zhang, A., Joormann, J., Kober, H.: Connections during crisis: Adolescents' social dynamics and mental health during COVID-19. Developmental Psychology **57**(10), 1633 (2021)
7. Hawrilenko, M., Kroshus, E., Tandon, P., Christakis, D.: The association between school closures and child mental health during covid-19. JAMA network open **4**(9), e2124092–e2124092 (2021)
8. Jones, S.E., Ethier, K.A., Hertz, M., DeGue, S., Le, V.D., Thornton, J., Lim, C., Dittus, P.J., Geda, S.: Mental health, suicidality, and connectedness among high school students during the COVID-19 pandemic—Adolescent Behaviors and Experiences Survey, United States, January–June 2021. MMWR supplements **71**(3), 16 (2022)
9. Lai, C.C., Lee, P.I., Hsueh, P.R.: How Taiwan has responded to COVID-19 and how COVID-19 has affected Taiwan, 2020-2022. Journal of Microbiology, Immunology and Infection (2023)
10. Martinsone, B., Stokenberga, I., Damberga, I., Supe, I., Simões, C., Lebre, P., Canha, L., Santos, M., Santos, A.C., Fonseca, A.M., et al.: Adolescent social emotional skills, resilience and behavioral problems during the COVID-19 pandemic: A longitudinal study in three european countries. Frontiers in Psychiatry **13**, 942692 (2022)
11. Noon, E.J., Meier, A.: Inspired by friends: Adolescents' network homophily moderates the relationship between social comparison, envy, and inspiration on Instagram. Cyberpsychology, Behavior, and Social Networking **22**(12), 787–793 (2019)
12. O'Kane, S.M., Lahart, I.M., Gallagher, A.M., Carlin, A., Faulkner, M., Jago, R., Murphy, M.H.: Changes in physical activity, sleep, mental health, and social media use during COVID-19 lockdown among adolescent girls: a mixed-methods study. Journal of Physical Activity and Health **18**(6), 677–685 (2021)
13. Tsai, C.S.: Staying Connected & Healthy: Exploring the impact of the COVID-19 pandemic on friendship networks and well-being of high school students (2023)