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Research Article

# Sparse, Pair-Wise, Emotion-Focused Interactions: Educators' Networking Patterns on Twitter at Early Pandemic

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**ABSTRACT**

Educators have increasingly turned to social media for their instructional, social, and emotional needs during the COVID-19 pandemic. In order to see where support and professional development would be needed and how the educational community interacted online, we sought to use existing Twitter data to examine potential educators' networking and discourse patterns. Specifically, this mixed-methods study explores how educators used Twitter as a platform to seek and share resources and support during the transition to remote teaching around the start of massive school closures due to the pandemic. Based on a public COVID-19 Twitter chatter database, tweets from late March to early April 2020 were searched using educational keywords and analyzed using social network analysis and thematic analysis. Social network analysis findings indicate that the support networks for educators on Twitter were sparse and consisted of mainly small, exclusive communities. The networks featured one-on-one interactions during the early pandemic, highlighting that there were few large conversations that most educators were part of but rather many small ones. Thematic analysis findings further suggest that both informational and nurturant support were relatively equally present on Twitter among educators, particularly pedagogical content knowledge and gratitude. This study adds to an understanding of the educational networks as a means of professional and personal support. Additionally, findings present the discourse featured in educator networks at the onset of an educational emergency (i.e., COVID-19) as decentralized as well as desiring pedagogical content knowledge and emotional sharing.

**Keywords:** data science applications in education, emergency online learning, Twitter, teacher professional development, social network analysis

## INTRODUCTION

Due to the COVID-19 pandemic, over 60% of students were not in school worldwide in 2020 (UNESCO, 2020). Even in the best times, switching from face-to-face to online/hybrid teaching environments poses challenges to teachers; these challenges include but are not limited to technological use, online pedagogy, time management, communication barriers, and the changing role (Jacobs & Rogers, 1997; Kebritchi et al., 2017). These changes require additional competencies and skills (Darabi et al., 2006), including the technological, pedagogical, and content knowledge (TPACK) for technological integration in teaching proposed by Mishra and Koehler (2006).

For many educators, the challenges go beyond switching to unfamiliar teaching environments to issues of work-life balance, child/elderly care, economic instabilities, and psychological traumas associated with the pandemic (e.g., Hjálmsdóttir & Bjarnadóttir, 2021; Purwanto et al., 2020). If teachers cannot obtain the personal and professional support they need to adapt to this new instruction version, students, particularly poor and historically marginalized students, may fall behind.

Teachers often turn to social media for personalized professional development by creating "personal learning networks" (PLNs) (Forte et al., 2012; Trust, 2012). The value of social media in supporting educators' informal learning and networking has been more prominent during the COVID-19 pandemic as formal, face-to-face professional development and networking became unavailable; particularly, social media became crucial for educators to seek advice and support in the transition to remote teaching in COVID-19 (Mancinelli, 2020). As one of the most well-known social media applications, Twitter has gained popularity among educators recently due to its many advantages. For instance, there is no negotiation of "friending" others (Prestridge, 2019). In addition, Twitter has been found convenient for sharing professional and personal advice, especially for teachers with less access to in-person professional networks, such as pre-service rural teachers (Zimmerle & Lambert, 2019). Greenhalgh et al. (2021) also argue that Twitter provides a rich space for research on education issues, in terms of not only teaching and learning per se but also education as part of greater society and culture.

Scholarly efforts, especially in recent years, have been put into taking advantage of a large quantity of Twitter data as it pertains to educational topics, particularly regarding the following topics: educators' professional activities (e.g., Carpenter et al., 2020; Veletsianos et al., 2019), rationales behind educators' social media participation (e.g., Carpenter & Krutka, 2014; Staudt Willet, 2019), and the role of social media (Twitter included) in facilitating social change such as advocacy and democratization (e.g., Supovitz et al., 2020; Torphy et al., 2020). However, research has been limited that utilizes interdisciplinary methods including data mining and social network analysis in conjunction with qualitative interpretations to explore educators' participation mechanism and interactive patterns on social media/informal computer systems. This study is needed as it fills the methodological gap by investigating *content* and the *nature* of online social support networks at the beginning phase of an educational emergency, when abrupt changes to teaching norms happen. While some research documents that educators used Twitter to pivot during COVID-19 (Rosell-Aguilar, 2021), there is less research on how Twitter was used for networking.

Burnett (2000) categorized two types of messages in online interactions: non-informational and informational messages. Non-informational messages are emotion-oriented, and informational messages are more professional and practice-oriented and rich in response queries. This mixed-methods study adapts this categorization for the purpose of investigating online support networks and discourse patterns for educators on Twitter around the beginning of school shutdowns in March and April 2020. By understanding how educators engage with social media from network and discourse perspectives, schools, policymakers, and society can better understand educators' needs and provide them with more targeted support in the online space at the onset of similar crises. The term "educators" in this study is used interchangeably with "teachers" and is defined broadly as anyone with teaching responsibilities in PK-20 school systems. The research questions are, as follows:

1. What type(s) of support networks for educators can be identified on Twitter during the transition to remote teaching in COVID-19?
2. What were the features of the overall support network and its subgroups for educators on Twitter?
3. Were there any influential figures in the support network and its subgroups?
4. What were the major communities in the support network, if there were any?

## LITERATURE REVIEW

Professional communities were at the "epicenter of the fight against the pandemic" (Azorín, 2020, p. 381). The COVID-19 pandemic disrupted not only student learning but also traditional professional development and networking for teachers that are often in-person and structurally implemented. Educators benefit from professional development and networks to support effective student learning (Avalos, 2011). At the early phase of the coronavirus pandemic, educators without proper training and support were underprepared to teach online/hybrid as it requires specific types of knowledge and skills, such as technological integration (Moore-Adams et al., 2016). In the recent decade, informal online communities and networks empowered by the internet have gained traction as a source of teacher professional development (Elliott, 2017; Macià & García, 2016). Many teachers participated in blogs, wikis, forums, instant messaging, and social networking

sites daily prior to the pandemic (Haythornthwaite, 2009). These self-initiated informal learning and networking activities continued to be professional development opportunities for educators during the pandemic as a safer alternative, and social media has served as an important platform for these activities.

Thanks to its widespread access and low-cost availability, social media applications such as Twitter, Facebook, and LinkedIn have played an increasingly significant role in teachers' professional development, networking, collaboration, and resource sharing (Bruguera et al., 2019; Greenhow et al., 2018; Hunter & Hall, 2018). Even before the COVID-19 pandemic, educators turned to social media for personal, professional, and instructional purposes (Quintanilla, 2016). Since the pandemic, social media has been particularly crucial for teachers and other educational stakeholders (e.g., students, parents, and school administrators) to seek advice and support (Mancinelli, 2020). Somewhat different from formal and traditional professional development opportunities, the informal, bottom-up online networks formed on social media offer educators the opportunity to "voluntarily engage in shared learning, reflect about teaching practice, and receive emotional support" (Macià & García, 2016, p. 291). Social media thus serves as an essential source of professional development and informal learning for educators. In addition, there is evidence of increasing formalization of professional development using Twitter, as demonstrated in Francera's (2021) work that creates a scale to measure principal leadership in using Twitter for professional development.

Further, social media provides researchers from various disciplines with a rich data source about individuals, society, and the world at large (Schoen et al., 2013). Social media mining and analysis have gained popularity among researchers in the social sciences and other fields to reveal insights about public opinions, sentiments, interactions, and social phenomena. For example, Wesely (2013) investigated the community of practice of language educators on Twitter qualitatively as a participant-observer. Greenhalgh et al. (2020) compared chat-related tweets (synchronous) and non-chat-related (asynchronous) tweets, demonstrating in their analysis that chat-related tweets are more likely to be used to share emotional support while non-chat-related tweets are more likely for resource sharing prior to the COVID-19 pandemic. Their study continues Greenhalgh and Koehler's (2017) "just in time" teacher professional development. Carpenter et al. (2021) analyzed tweets featuring #remoteteaching and #remotelearning at the onset of COVID-19. They found education stakeholders used these hashtags as spaces for professional knowledge sharing, social sharing, and self-promotion when teaching remotely.

While these studies are examples of attempts to venture into social media data to understand online teacher communities, scholars argue that using a single method (qualitative or quantitative) alone is not adequate to understand the complex nature of social networks and interactions online (Ranieri et al., 2012; Schlager et al., 2009). Mixed methods that combine traditional educational research approaches (e.g., thematic analysis) and interdisciplinary approaches (e.g., data mining, network analysis, and visualization) can shed new light on participation mechanisms and the evolution of these online environments (De Latt & Schreus, 2013). In light of the scarcity of mixed-methods design on social media data in education, this current research uses Greenhalgh (2021) and Marcelo and Marcelo (2020) as examples for thematic analysis (former) and social network analysis (latter).

Researchers have tried to observe online support groups/networks and categorize patterns in order to understand the participation mechanism in these non-traditional communities. Drawing upon theoretical and empirical works on an environmental model of human interactive behaviors in virtual communities, Burnett (2000) categorizes two significant types of messages in online interactions: non-informational (emotional) and informational messages (practical). This categorization is similar to that of Zhang et al. (2017) who used social network analysis (SNA) to analyze teacher interactions on message boards in online professional development courses. They also observed two broad types of support online: informational (professional/practical) and nurturant (personal/ emotional) support. By analyzing posts in three online communities and interviewing members in those communities, Hur and Brush (2009) postulate five reasons educators participate in online communities of educators:

a. sharing emotions,
b. utilizing the advantages of online environments,
c. combating teacher isolation,
d. exploring ideas, and

e. experiencing a sense of camaraderie.

These different categorizations share a similarity of the professional and affective dual in educators' online interactions.

### Twitter for Educators

Twitter is an open-access social media platform where its registered users can post texts (i.e., "tweets") of limited length (280 characters) and interact with other users' tweets through the act of "like," "reply," and "retweet." In addition, Twitter users can add hashtags (#) to their tweets to indicate their membership in a particular discourse community sharing similar topics. Twitter has a large user base (over 60 million users) and encourages text-based discourse and debate. It also has a relatively open policy regarding data sharing for research purposes. For these reasons, Twitter data has attracted much attention in social science research in recent years (Lee-Johnson & Henderson, 2019). For an impactful social event such as COVID-19, social media data from popular platforms such as Twitter has great potential of providing useful insights about the public interactions and sentiment regarding a particular topic in the upheaval of an emergency, which has not been frequently studied or thoroughly understood in the literature. Mining and analyzing Twitter data can further inform public policies and various levels of decision-making, especially during similar emergencies and crises (Beigi et al., 2016; Conrado et al., 2016; Gilani et al., 2019).

Studies have explored how and why educators engage with Twitter as a social media platform. Carpenter and Krutka (2014) surveyed K-16 educators and found that educators commonly use Twitter for professional development purposes and value the personalized, immediate nature of Twitter, as well as the positive and collaborative community it facilitates. Twitter's role in combating isolation was also highlighted in the survey responses as educators use Twitter to engage with peers and share a sense of camaraderie; the advantage of this may have proved more valuable in the time of the COVID-19 pandemic where isolation was pervasive. Staudt Willet (2019) revisited Carpenter and Krutka's (2014) survey study by investigating one of Twitter's oldest education hashtags, #Edchat, from 2017 to 2018. Through a combination of human and machine coding of over one million unique #Edchat tweets, their study found that the #Edchat hashtag has been effectively utilized for exploring ideas but less so for sharing emotions (Staudt Willet, 2019). These studies illuminate the typical rationales behind educators' engagement with Twitter and the discourse features of some of these interactions. However, research exploring the network features in conjunction with the discourse patterns among educators on Twitter, especially in the context of an early-phase educational crisis (e.g., the COVID-19 pandemic), is yet to emerge.

Inspired by previous scholarly work on Twitter use among educators (e.g., Carpenter & Krutka, 2014; Carpenter et al., 2021; Staudt Willet, 2019), this study adopts the affinity space framework by Gee (2004). An "affinity space" is a physical, digital, or blended environment where people form affinity by gathering around a common topic of interest. This concept differs from community-based theories such as community of practice (Lave & Wenger, 1991) in that affinity spaces are much more open and flexible in terms of time, geography, and levels of engagement with the content of the space. The openness of affinity spaces leads to an investigative emphasis on different ways people join and engage with the space (Gee, 2004). Framing the affinity space under investigation as the Twitter space defined by the topic of online/remote learning in the early COVID-19 pandemic, this study seeks to fill the gap of scholarly understanding of the participation rationale and mechanism of educators in Twitter spaces by exploring features of networks and themes of the interactions/discussions at the onset of an educational emergency.

## METHODOLOGY

### Research Design

This study adopts a mixed methods design (Creswell & Clark, 2007; Tashakkori & Teddie, 2003) to examine the nature of interactions and discourse in educators' networks on Twitter around the beginning of school closures (March 22 to April 4, 2020). SNA is used to quantitatively identify the educators' network's features and sub-groups/communities on Twitter. SNA has been increasingly adopted in educational research in the past few years. For instance, Zhang et al. (2017) employed SNA to analyze teacher interaction on message

boards in online professional development courses. Further, qualitative thematic analysis was used to identify discourse patterns that capture crucial information (Braun & Clarke, 2006) about the Twitter data (i.e., tweets) featured in the social networks. The "themes" or "patterns" that emerged from the Twitter data resulted from thematic analysis represent reoccurring meanings across the tweets and contribute to the interpretation of the phenomena (Vaismoradi et al., 2013), which in the case of this study refers to how educators reacted to the abrupt changes brought by the COVID-19 pandemic.

## Dataset

This study adopted a large-scale, open-access COVID-19 dataset by Banda et al. (2020), who used Twitter stream API to capture all tweets with keywords including "COVD19", "CoronavirusPandemic", "COVID-19", "2019nCoV", "CoronaOutbreak," "coronavirus," and "WuhanVirus." We downloaded and hydrated the tweets from March 22 to April 4, 2020, with Python programming language (codes sharable upon request), as this was the time when schools started to close and switch to remote mode at a large scale (EducationWeek, 2020).

## Sampling

Data was selected manually with the aid of keyword search ("online") from the hydrated dataset using two criteria:

1. Tweets that are directed (i.e., with replies) and
2. Tweets that address educators' transition to online teaching.

The first sampling criterion was determined because social networks on Twitter were defined by nodes/actors (i.e., individuals with unique Twitter ID) and edges (i.e., tweet replies from one user to another) in this study. The networks thus are "directed" (as opposed to "non-directed") with directions from the replier to the replied. We decided that the links only represented direct replies and did not include retweets (re-sharing of tweets), as the focus was on interactions during a time of need. This addresses concerns with construct validity as the links were narrowly rather than broadly defined (Howinson et al., 2011). The second sampling criterion demonstrates a nominalist approach to sampling, where individuals were selected based on theoretical concerns (Wasserman & Faust, 1994), because we were primarily interested in how educators discussed and interacted around online teaching at the beginning of the pandemic. The term "educator" here is broadly defined to capture teachers/instructors in PK-20. Most existing Twitter research in education adopts a hashtag-searching method for sampling (e.g., Carpenter et al., 2020; Greenhalgh, 2021; Rosenberg et al., 2016). Keyword (rather than hashtag) sampling was chosen in this study out of a concern that not all Twitter users incorporate hashtags in their posts. Thus, using keyword filtering may yield richer search results. Based on these criteria, the final dataset consisted of 185 nodes and 96 edges.

## Analysis

This study used SNA to investigate networking mechanisms among educators on Twitter and thematic analysis for a closer examination of their discussions surrounding issues related to online/remote teaching in the early pandemic. SNA was assisted by Gephi, a widely adopted free-access software for network analysis and visualization (Bastian et al., 2009).

To identify types of support present on Twitter, thematic analysis was conducted manually using open coding, a qualitative method that breaks down text into discrete parts and compares them thematically (Saldaña, 2016). The two researchers blindly coded half of the tweets and met to discuss the codes line-by-line until a satisfactory level of interrater agreement on the themes was reached. This is a way to ensure the trustworthiness of qualitative interpretations through social moderation (Herrenkohl & Cornelius, 2013). Then the researchers divided up to code the rest of the tweets in the dataset.

The network was analyzed as a whole and as subgroups identified by qualitative (thematic) analysis. Network diameter, density, centrality, and modularity-based measures were identified. The network diameter is the length of the largest geodesic distance between any pair of nodes (Wasserman & Faust, 1994). This provides a general idea of the ease for one Twitter user to reach another in the teacher support network. The density of a graph is the proportion of lines present in the graph out of the maximum possible edges in the graph (Wasserman & Faust, 1994). This helps to determine the connectedness of the network. Eigenvector

centrality (EC), one of the best-known centrality measures for directed networks (Landherr et al., 2010), was used to identify the most important actors in the teacher support network and its subgroups. Modularity-based measures were used to identify smaller communities within the teacher support network. Modularity-based subgroups are cliques: groups of social exclusiveness (Wasserman & Faust, 1994). There are multiple ways to identify cliques. Gephi integrates the Louvain method, which determines communities by comparing the relative density inside with that outside of the community (Blondel et al., 2008).

Discussions of validity and reliability of SNA with digital trace data are limited in existing literature because of its emerging nature (Howison et al., 2011). In order to analyze digital trace data, it is important to first define what it is. Howinson et al. (2011) define digital trace data in terms of three main characteristics:

1. Data pre-exist before collection,
2. Data are event-based, and
3. Data are longitudinal.

Shadish et al. (2001) describe four types of validity concerning research with trace data: construct validity, statistical conclusion validity, internal validity, and external validity. However, Howinson et al. (2011) argue that as digital trace data does not deal with external validity, it does not need to concern researchers using SNA. This study ensures other forms of validity with the following strategies:

1. The networks under investigation, including the nodes and edges that constituted the networks, were clearly defined;
2. Appropriate network measures were used and described with credible references; and
3. The chain of reasoning was aligned with affinity space theory where affinity spaces were defined by common tweet topics (i.e., online teaching in COVID).

Despite a general assumption that digital trace data are inherently reliable, there are certain steps that need to be taken in order to ensure reliability (Howinson et al., 2011). In the case of this study, two researchers manually sorted the dataset to ensure that irrelevant tweets such as advertisements were excluded from the analysis.

## FINDINGS

### Type(s) of Support Networks for Educators

Two types of support and two subgroups accordingly were identified in this network through open coding (**Appendix A**). The actors in the informational subgroup shared useful information/advice regarding teaching online. Those in the nurturant group shared emotional support, predominantly appreciation for educators' efforts.

#### *Informational subgroup*

Three major themes emerged from the thematic analysis of the informational subgroup: resource sharing, technological pedagogical knowledge (TPK), and practical advice.

Resources sharing happened in various forms. Some educators shared lesson plans that had worked well for them:

> "I have put together a homework asking my students to model the effects of COVID-19 using the models in the economy..."

Other resources came from educator support organizations such as teaching tolerance (Teaching Tolerance, 2020).

TPK refers to knowledge of the capabilities of various technologies as used in teaching and learning (Mishra & Koehler, 2006). This is where there were the most tweets in this subgroup. Tweets concerning TPK came from companies like Zoom and school districts:

> "@YtownSchools teachers use creative strategies (of TPK) to reach students during shutdown..."

**Table 1.** Results of social network analysis of the whole network and its subgroups

| Graph | Number of actors (nodes) | Number of replies (edges) | Diameter | Density | EC (# of nodes) |
|---|---|---|---|---|---|
| Informational support subgroup | 74 | 37 | 1 | 0.007 | 0 (38)<br>0.5 (35)<br>1 (1) |
| Nurturant support subgroup | 80 | 44 | 1 | 0.007 | 0 (42)<br>0.2 (37)<br>1 (1) |
| Whole network | 185 | 96 | 1 | 0.003 | 0 (95)<br>0.2 (87)<br>0.4 (2)<br>1 (1) |

The third theme was practical advice on how to teach remotely. These tweets shared personal successes without providing concrete resources or skill development. They came from educational researchers, teachers, and school leaders. Educational researcher Hattie (2020), for instance, shared a video about the transition to remote teaching (#Visible Learning).

### *Nurturant Subgroup*

Three themes emerged from open coding of tweets in the nurturant subgroup: gratitude/appreciation, understanding/concern, and encouragement.

Most tweets in this subgroup shared appreciation towards educators who made it possible for students to learn from home. "#teachersareheros" was a popular hashtag. For instance, one user tweeted:

> "Caring for family AND for students while adapting modules to #OnlineTeaching… has been incredibly challenging… So a big big thank you!"

Tweets like this expressed sincere gratitude while recognizing educators' difficulties in balancing teaching and family duties.

The theme of understanding/concern, often appearing together with gratitude, demonstrated understanding of and concern towards teachers' situations. Some recognized the increasing workload in the remote modality:

> "there are actually more work assigned when the kids don't have to come into school……same goes for teachers."

The last theme in the nurturant subgroup was encouragement: cheering and uplifting messages directed to teachers. These tweets often came from members of the teaching community to emphasize solidarity. "#StrongerTogether" "#WeGotThis" and "#proudteachers" were all hashtags to show alliance and emotional support.

## Features of Support Networks for Educators

SNA findings indicate that the whole educator support network and its two subgroups were sparsely connected graphs. This suggests that Twitter may not yet be the main platform for the education community to share support and/or that Twitter users had not started interacting regarding COVID-19 teaching at a large scale in the early pandemic.

For the whole network (**Table 1**), there were 185 nodes/actors and 96 edges, meaning there were 185 Twitter users who posted 96 replies to one another. The network diameter is 1 with a low density of 0.003, indicating that although it was easy for a user to reach another, there were not many interactions happening in the network overall.

The informational subgroup has 74 actors and 37 edges. The nurturant subgroup has 80 actors and 44 edges, with slightly more active users and interactions than the informational subgroup. These means Twitter users were more likely to share emotional support than practical information during that time.

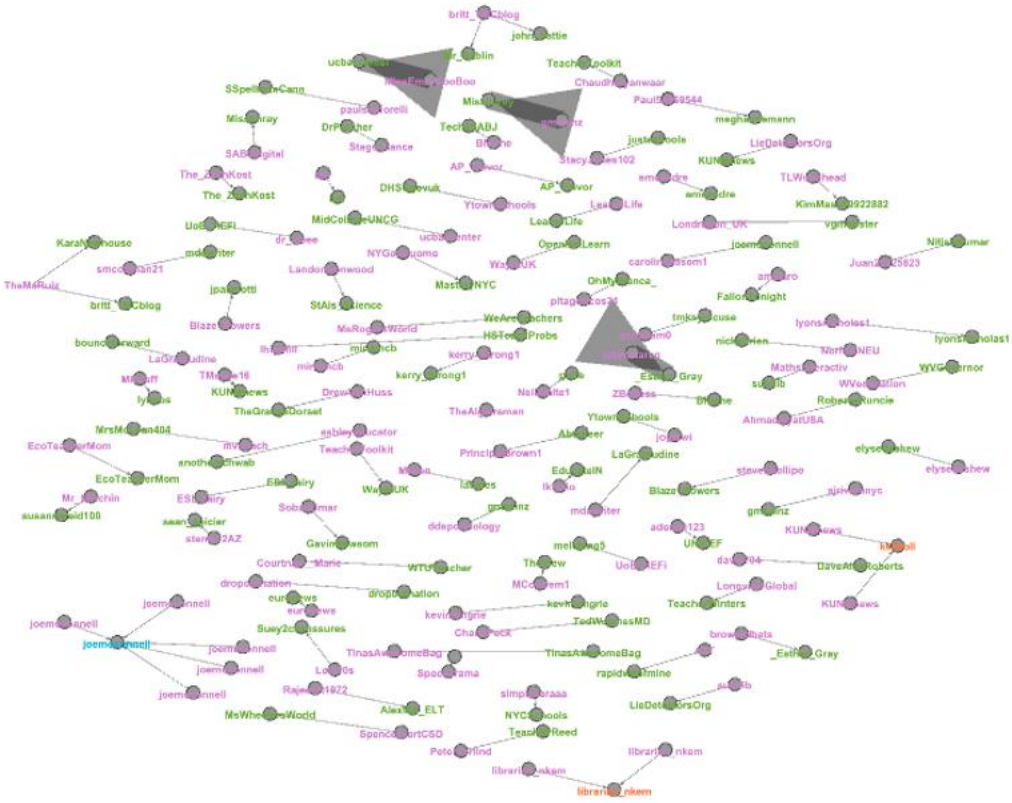

**Figure 1.** Eigenvector centrality–Whole network

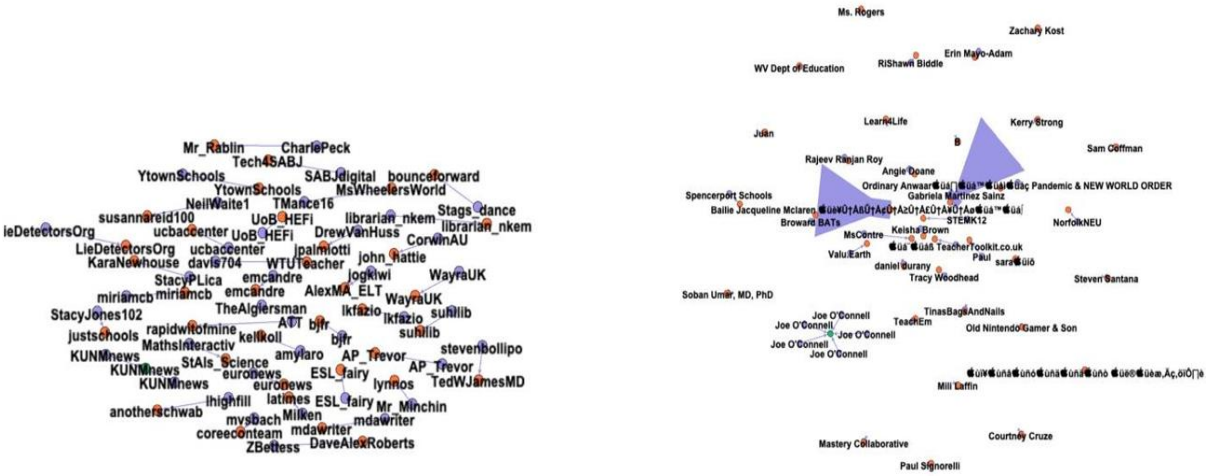


**Figure 2.** Eigenvector centrality–Informational subgroup and nurturant subgroup

## Influential Figures in Support Networks for Educators

Influential figures were identified using the EC measure. For the whole network (**Figure 1**), the EC ranges from 0 to 1, with most nodes earning a zero, two nodes earning a 0.4, and one node earning a 1, meaning most of the users were not important, two users were of moderate importance, and one was of the most importance.

In the informational subgroup (**Figure 2**), 51.4% (n=38) of the actors had an EC of 0, demonstrating no importance. 47.3% (n=35) had an EC of 0.5, demonstrating moderate importance. One actor had an EC of 1, making it the central node in the subgroup. EC in the nurturant group also ranged from 0 to 1. 52.5% (n=42) of the nodes have an EC of 0. 46.3% (n=37) had an EC of 0.2. One node had an EC of 1. Thus, there was only one central figure in the informational and nurturant subgroup, respectively.

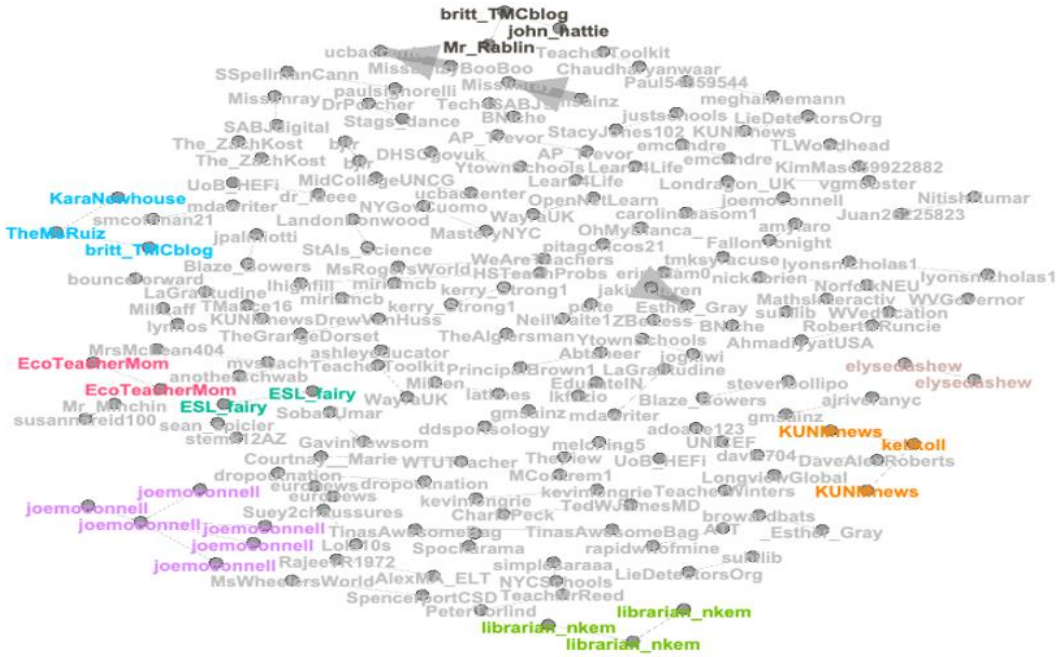


**Figure 3.** Modularity-based subgroups–Whole network

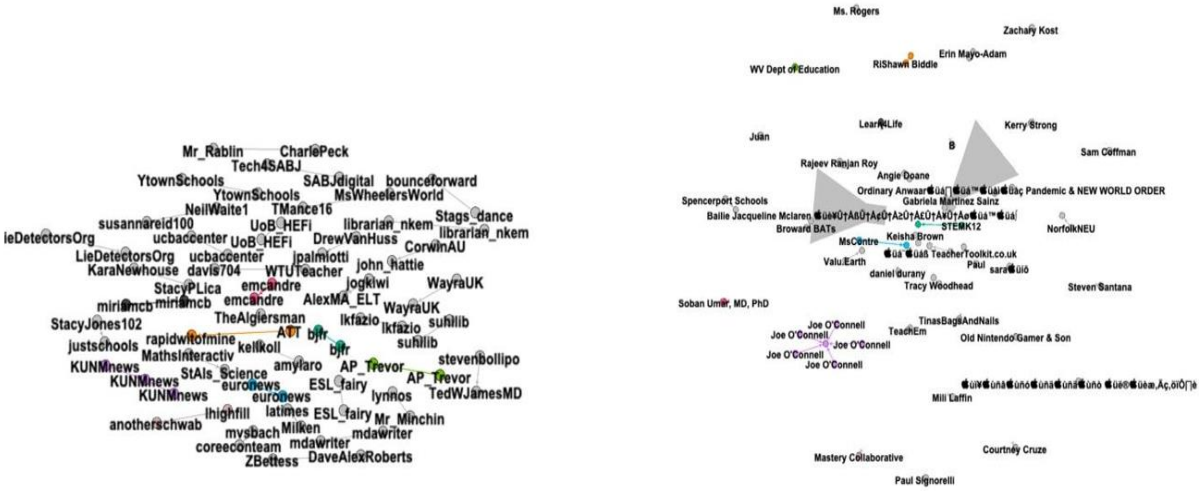


**Figure 4.** Modularity based subgroups–Informational subgroup and nurturant subgroup

## Modularity-Based Communities

There were four modularity-based communities in the whole network with a weight above the 1.5% threshold among a total of 88 communities, the highest weight being 3.26%. Given the small size of the network, this means there were many tiny communities in the network. **Figure 3** shows most of the communities consisted of pairs of users, and there was no predominant community. The overall modularity measure was 0.986 (in a standard range of -1.5-1), meaning the network was very close to fully modular clustering, and the communities were exclusive. In other words, Twitter users in the network mainly interacted with member(s) in their own community and rarely with users outside. The subgroups demonstrated similar features as the entire network in terms of modularity (**Figure 4**). One major (yet not dominant) community can be identified in each subgroup. Note that there was one main community in the informational subgroup with the weight of 4.1%. All other communities had a weight of 2.7%. The overall modularity of the informational subgroup was 0.972. In the nurturant group, there was also one main community with a weight of 7.5%, and all other communities had a weight of 2.5%. The overall modularity value of the nurturant subgroup was 0.965.

## CONCLUSION AND DISCUSSION

This mixed-methods study adopts social network analysis and qualitative thematic analysis to explore the network features and online discourse in support networks for educators on Twitter surrounding the topic of online teaching around the beginning of majority COVID-19 school closures (i.e., late March to early April 2020). The study is significant in that it helps to identify network features and types of support available to educators on social media. In response to research question 2, the overall support network for educators ended up being a loose collection of nodes and was not tightly interconnected. There were less than 200 actors with less than 100 edges in total. Much of this had to do with sampling decisions, but it also speaks to where and how educators solicited support and advice in the early pandemic. Educators and the education-concerning public may not use Twitter as their primary channel to provide or seek help during that period. Given the challenges of emergency remote teaching, the role of social media, and the importance of networks in teachers' professional development discussed in the literature, it seems that Twitter did not shown its full potential in forming robust support networks at the onset of the educational crisis induced by COVID-19. Although the educator communities on Twitter were not well-established at the beginning, Twitter's role in supporting and allying educators in crisis, especially in an emotional and affective way, has been manifested in the findings. This is consistent with Carpenter and Krutka's (2014) survey findings that underscore Twitter's role in combating isolation for educators.

Qualitative analysis suggests the whole network can be divided into two discourse-based subgroups (informational & nurturant) based on the types of support patterns featured in the tweets (research question 1). Informational support tweets had three major sub-categories emerge: resources, technological pedagogical knowledge, and advice. Technological pedagogical content knowledge ended up being the most popular type of information shared in this discourse subgroup. The nurturant support subgroup was largely non-informational and affective, which featured three thematic categories: gratitude/appreciation, understanding, and encouragement. The nurturant support findings confirm Hur and Brush's (2009) proposition that educators use social media to combat isolation and promote camaraderie. However, when comparing the two discourse subgroups in this study, non-informational (emotional/affective) support was more prominent than informational (practical/professional) support. This contradicts Staudt Willet's (2019) findings that suggest educational tweets (with #Edchat) were somewhat under-utilized for emotional support among educators. The larger size of the nurturant subgroup compared to the informational subgroup suggests that educators may have needed emotional and personal-level support more than professional support at the beginning of an educational crisis. It seems that Twitter also provided a space for individuals to request and share broad emotional support from a larger community than that of educators, much like what was happening with healthcare workers. Those who were looking for targeted professional support may have turned to other platforms targeted at providing those resources or closed groups of known educators. This points to a need to reconceptualize the "affinity space" framework against a context of an educational emergency, particular at the onset of a crisis: When researching educational computer systems on this framework, rather than focusing only on the topics or content of common interest as a bond in an "affinity space", there is merit in discussing emotional bonds among educators as a form of affinity in online spaces.

To address research question 3, the eigenvector and page rank centrality measures of the whole network and its subgroups indicated that there was a very small number of active Twitter users who were relatively more influential than the other users. However, considering the loose connections and the low number of connections of those central characters, their impact was only comparatively larger than others. The Louvain modularity measures indicated that the entire support network consisted of a large number of modular clustering, which were small and exclusive. This means that in the whole network and different types of support subgroups, most supportive interactions happened one-on-one or among a small number of Twitter users who may not interact with the rest of the network (research question 4). While this indicates that educators have started to turn to Twitter to share support with peers at the beginning of the COVID-19 upheaval, interactions were happening at a small scale, and a sense of well-connected communities was not yet formed. It is unclear whether this was related to the nature of Twitter as a platform, the type or manner of support sought out by teachers, or the lack of general awareness about the value of social media at the start of the crisis.

Carpenter et al.'s (2021) analysis of educators tweeting at the onset of the COVID-19 pandemic shares multiple similarities with this study regarding the context, the social media platform, and a focus on educators' sentiment around teaching remotely; yet this study has its unique contributions in the following two ways:

1. During data curation, this work adopted a keyword searching method based on an existing COVID-19 Twitter chatter dataset rather than using hashtag(#) searches among all tweets directly from Twitter. This choice was made considering the possibility that not all Twitter users are familiar or comfortable with using the hashtag function that Twitter offers.
2. This study does not only examine *what* educators discussed in the Twitter affinity spaces but also *how* they engaged with each other when the pandemic crisis started; this is archived by triangulating qualitative interpretations with social network analysis.

And the most prominent finding from this work is that at the onset of the pandemic, educators' Twitter interactions surrounding the topic of online teaching/learning featured one-on-one, small-scale discussions with few influential figures and more emotional (rather than informational/professional) sharing.

## Limitations and Future Research

The scope of this study is limited to one social media platform whose users may not represent all educators. Twitter users have been found to share certain demographic features (Mislove et al., 2011). Hunter and Hall (2018) found that K-12 teachers in the United States who regularly engage with social media show higher comfort and trust in social networks/technologies and are more likely to work in urban schools in the Northeast region. This could mean that the study sample can be overrepresented by these tech-savvy, urban educator populations and under-represented by educators who needed extra technological support in this transition in suburban or rural contexts. These underrepresented educators on social media could be encouraged by their institutions to take advantage of social media and other online services as sources for professional learning and networking. More research is needed to investigate alternative ways other than social media educators could turn to for support at the onset of a crisis.

Another limitation is that this study assumes that a majority of Twitter users, if not all, who discussed online teaching in the context of early COVID-19 were educators. Admittedly it is likely that keyword-sampling can result in other educational stakeholders (e.g., parents, school leaders, educational policymakers) being included in the final dataset. Due to the largely anonymized nature of social media posts and privacy concerns, it is difficult for Twitter researchers to know the true identity of participants. There is a trade-off when using computational methods to curate (e.g., social media scraping with keyword-filtering) and analyze (e.g., SNA) large datasets because some contextual information such as participant background is inevitably lost. Further, Twitter's free API used in this study limits access to certain information, such as geographic locations. These explain why this study does not distinguish educators working at different levels (e.g., pre-school versus higher education) and from different regions with varying experiences in the early pandemic.

Findings from this research point to several directions for future studies. Firstly, there is potential to expand this line of work to alternative social media platforms, timeframes, and geo-graphics. Facebook, LinkedIn, and other alternative social media may have private groups dedicated to discussions and support for educators. Comparing and contrasting educators' use of different platforms can provide additional insights (Carpenter et al., 2021). Analyzing alternative networks such as these in a more extended timeframe or at different pandemic stages may also lead to more cohesive networks and nuanced findings. For example, Greenhalgh (2021) uses the dimensions of sharing, volume, and intimacy to evaluate regional educational Twitter networks, and this could be another approach for examining education and Twitter during COVID-19.

Similarly, this line of work can continue into the future as schools look to balance health and safety with returning students to the classroom after vaccination. Different types of Twitter API grant different access to Twitter data, and researchers with access to geographic locations, for instance, can build upon this study to conduct cross-region comparisons regarding Twitter discourse in the pandemic. Secondly, this work does not differentiate between educators working at different levels, as discussed above. While most of the tweets we examined closely appeared to be directed at K-12 teachers, a better delineation between different educator groups could also prove interesting and have the potential to illuminate the different challenges they were facing. This may require triangulation with in-depth interpretations of tweets and lines of inquiry into the

perceptions of Twitter users with surveys and interviews. Finally, this research does not address issues of access and equity. It would be beneficial to explore educators' social media engagement at schools in low-income communities that have navigated this transition compared to their colleagues in better-funded schools and districts.

## Implications

Despite the limitations, this research helps shine a light on the experiences of educators in the transition to online teaching around the beginning of the COVID-19 pandemic. Social media, or Twitter specifically, seems to be overall under-utilized at the onset of the pandemic as a resource among educators, given the low connectedness and a lack of influential figures or larger sub-communities. Based on these findings, there is a need for educators to take more advantage of alternative means of developing professionally and finding support in times of adversity; one of the means is through forming PLNs in informal computer systems, particularly information-rich, open-resource platforms such as Twitter or MOOCs (Tang, 2021). Online PLNs support educators' growth cognitively, affectively, and socially, and are less restricted by time and space (Trust et al., 2016). SNA findings reveal several potential paths to grow PLNs on social media and similar computer systems, including but not limited to

a. increased participation from the wider educational community,
b. engagement from influential characters in education (e.g., government agencies, prestigious scholars, well-known organization representatives, exemplar teachers), and
c. active cultivation of online dialogues and interactions that reflect common concerns from educators (so that substantial sub-communities and larger dialogues can be formed).

Further, thematic analyses point to the fact that at the initial phase of an educational emergency, educators need not only practical advice and teaching resources (e.g., TPACK) but also emotional support from peers (e.g., comraderies) and the public (e.g., acknowledgment, appreciation). Pre-service teachers should receive instruction in TPACK as Lachner et al. (2021) found pre-service teachers who had received explicit instruction left courses with more TPACK and technology-related self-efficacy than those without, and technological aptitude seems more crucial for educators in the pandemic and post-pandemic world. Social media literacy as a new form of literacy is also needed among educators (Carpenter, 2021; Nagle, 2018). Schools/institutions, professional organizations, policymakers, and the society at large need to listen and cater to the professional and emotional needs of teachers who continue to carry the responsibilities of educating the next generation in a time of crisis. This could mean providing time, flexibility, administrative support, and professional training needed by educators to adjust to the changes in the teaching norms. This could also mean acknowledging the diligent efforts (and sometimes sacrifices) educators had to make to continue teaching duties in the time of uncertainty and stress. Meanwhile, practitioners and researchers alike need to recognize the increasingly important role social media plays in connecting individuals, forming communities, and enabling information/support sharing in times of emergencies. Institutions and policies should encourage informal professional development and networking among educators on social media and other online tools during and beyond the pandemic as an affordable, flexible and self-directed way for educators' lifelong learning (Ranieri et al., 2012).

Methodologically, SNA has only recently been used in educational research on social media. By adopting SNA on large-scale digital trance data combined with qualitative analysis, this work adds to the literature that utilizes interdisciplinary approaches to explore educational topics pertaining to teachers' professional development and networking experiences. Schools may continue to implement some form of distance teaching as the coronavirus remains a threat. By better understanding how the education community shares support and the types of support educators need, society can better provide targeted, meaningful assistance.

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## APPENDIX A

**Table A.** Subgroups and their themes on Twitter emerged from qualitative analysis

| Subgroups | Themes | Example excerpt |
|---|---|---|
| Informational subgroup | Resource sharing | "I have put together a homework asking my students to model the effects of COVID-19 using the models in the economy…Would you be interested in sharing it with other teachers teaching the CORE?" |
| | Technological pedagogical knowledge | "@YtownSchools teachers use creative strategies to reach students during shutdown…" |
| | Practical advice | "You might like this. I am a teacher and I decided to make a coronavirus time capsule. I asked former students to tell me what was going on during this situation. It became a video from my former students to my future students. Hope you are well." |
| Nurturant subgroup | Gratitude/appreciation | "Caring for family AND for students while adapting modules to #OnlineTeaching and managing research projects to #SocialDistancing measures has been incredibly challenging…So a big big thank you!" |
| | Understanding/concern | "You know there are actually more work assigned when the kids don't have to come in to school…as opposed to when they did need to physically come in to school, same goes for teachers." |
| | Encouragement | "WeAreTeachers #CoronavirusPandemic #OnlineTeaching" |