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Discourse about higher education on Twitter in early phases of COVID-19: A crisis management social network analysis

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Abstract

The emergence of the COVID-19 pandemic brought changes and efforts for adaption to the new environment in every industry, including higher education. The present study, drawing on crisis management theory as a framework, aimed to understand information and communication sharing behaviors of the higher education community during the pandemic by exploring patterns and discourse on social media. Such analysis provides insight into how information is gained, shared, and used. Tweets including the hashtag *#highered* were retrieved at five time points in March and August 2020—M1 (retrieved on March 3), M2 (March 17), A1 (August 4), A2 (August 11), and A3 (August 18). Using a social network analysis tool, *NodeXL*, the collected tweets were analyzed by social network structure, topic, and influencer. Results showed that *#highered* was used widely in the early stages of the pandemic. The relevant conversation rapidly evolved, as did the prominent influencers. Over time, the conversation centered on the pandemic, the implications of the sudden shift to online learning, and then the subsequent effect on universities, students, faculty, and staff. A crisis preparation phase continued through August 2020, but drivers of information transitioned from well-known news outlets prior to the pandemic to individuals directly experiencing the pandemic. Future research should analyze the validity of information shared by individuals during key decision points of the pandemic and whether higher education is susceptible to the growing spread of disinformation through social media when formulating policy.

Keywords Higher education · #highered · COVID-19 Pandemic · Social media · Twitter · Social network analysis

Abbreviations

M1 retrieved on March 3

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M2 March 17
A1 August 4
A2 August 11
A3 August 18

1 Introduction

The COVID-19 virus compelled every industry, including higher education, to adapt to the spread of a global pandemic through unprecedented measures. By the end of February 2020, higher education institutions in the United States were making quick decisions about operations, despite limited information about the pandemic (American College Health Association, 2020). Higher education in the United States is historically and traditionally a highly decentralized system (Ross, 1977), with most of the over 6,000 colleges and universities serving over 19.4 million students while functioning as independent units (NCES, 2021). While institutional leaders often consult their counterparts at other institutions for significant decisions (Gigliotti, 2019), especially in the context of COVID-19 (Liu et al., 2021a), most decisions are made at the campus level based on the most immediately available data.

Information about COVID-19 and its potential effects on higher education, as well as scientific epidemiological information such as the spread and control of the virus, was scarce in March 2020 (Zhu & Park, 2021). As the virus advanced across campuses, higher education leaders were obligated to create and implement immediate transition plans for remote learning, living, and working among thousands of students, faculty, and staff (Bolumole, 2020; Lee & Jung, 2021; Yang, 2020). In addition to official communication channels such as campus-provided email, campus administrators used social media for crisis communication, as well as to monitor the latest trends and developments of the pandemic.

To date, several dissertations highlight the early studies on crisis management communication and the COVID-19 pandemic, mostly concerned with the transition to online instruction (e.g., Brunetti, 2021; Burt, 2021). For example, Cooper (2021) studied the transition to emergency remote teaching during the COVID-19 pandemic, using a case study approach with interviews of North Carolina community college faculty. Participants described their quick transition to online teaching with little preparation time, minimal curricular and technological support, and hardly any administrative guidance. Drawing on emergency preparation models, Cooper described how access to clear, comprehensive emergency contingency plans prior to the pandemic could have made the transition less difficult.

In this study, we explored patterns and discourse about higher education's response to COVID-19 using Twitter data during three key decision points. The first decision point (M1) was in early March 2020, as institutional leaders collated the evidence to date to respond to the spreading pandemic (March 3). Just over 2 weeks later (M2), nearly all higher education institutions in the United States announced transitions to virtual learning (March 17). As the virus continued to spread in the United States throughout the summer of 2020, institutional leaders faced another

key decision point about the potential return to campus for fall term (August 4, 11, and 18; A1, A2, and A3).

The purpose of this analysis was to identify the key influencers and the primary topics of conversation in the higher education sector during three important times of the pandemic. Social media data, and Twitter in particular, are uniquely useful as a snapshot of both information and sharing behaviors among individuals. At the time of the study, Twitter was consumed as a news and media source at its highest rate ever (Odabas, 2022), owing in part to its ubiquitous use by the U.S. President Donald Trump (Shear et al., 2019). Understanding who was talking (key influencers), what they were saying (discourse), and who was listening (the resulting network) in a major information sharing outlet during specifically chosen times of the pandemic provides a window into large scale crisis management in higher education. Although there have been crises on individual campuses, such as the tragic Virginia Tech shooting (Wang & Hutchins, 2010), and regional crises such as the effects of Hurricane Katrina on Gulf Coast institutions, there have been no large scale contemporary events that simultaneously affected the entirety of postsecondary education in the United States, despite warnings of the potential for a serious outbreak of illness from among crisis management scholars (Mitroff et al., 2006).

While the data were not directly analyzed from the accounts of institutional leaders, the population of tweeters reveals the decisions made, the most prominent information available at the time they were made, and the effects of those decisions on higher education stakeholders such as students, faculty, and staff during key early decision points of the COVID-19 spread. We found that the hashtag *#highered* was often used in the discourse surrounding institutional responses, becoming an emergent community of practice paired with #corona, #COVID19, #onlinelearning, and other hashtags.

1.1 Review of literature

1.1.1 Twitter as a news and discourse channel

Social media offers a platform for individuals to share information, including opportunities and frustrations. Different than information passively available on online news and information sites, Selwyn (2012) characterized social media as a large scale "participatory and collective activity" (para. 1). Researchers have shown that social media can be a key data source in understanding the spread and pattern of information, and discourse analysis can reveal population sentiments about a topic. In their review of over a decade of studies, Malik et al. (2019) identified Twitter as a pedagogical tool for students and teachers for obtaining information, engaging and interacting, participating in special interest communities, and sharing insights. In the larger public sphere, Xu et al. (2014) found Twitter is often used to disseminate important information and as a tool to drive public discourse.

Crisis-based information spread is not unique to either COVID-19 or the context of the United States, as researchers have investigated similar Twitter behavior among the Ebola health crisis (Jin et al., 2014) and the Manchester Arena bombing

in England (Hunt et al., 2020). Analysis of each of these events showcased how large groups of people felt and behaved, using data that otherwise would not be attainable without largescale surveys or interviews after the event. Analysis of social media data about widespread events provides useful insights to researchers in learning how information is gained, shared, and used. Early reports from Twitter analysis at the onset of the COVID-19 pandemic verified that as the virus spread, the world public turned to Twitter for news and information (Chong & Park, 2021; Park et al., 2021; Singh et al., 2020).

The COVID-19 pandemic has produced a host of divisive informational issues discussed in media including the use of face masks (Batova, 2021), COVID testing and vaccines, and lockdown policy (Yuzhang, 2021). Twitter in particular has been referred to as a "pandemic" for its role in the dissemination of medical misinformation (Tagliabue et al., 2020). Kouzy et al. (2020) analyzed tweets about the COVID-19 pandemic and found that 25% of the Tweets contained misinformation and 17% contained unverifiable information.

1.1.2 Social media and crisis communication

Communication researchers point out that "organizations no longer have a choice about whether to integrate social media into crisis management; the only choice is how to do so" (Jin et al., 2014, p. 76). During a crisis, social media allows organizations to address uncertainties and perceived risks through regular and strategic communication about the often rapidly changing situation (Biswas, 2013). Twitter has been shown to be a particularly effective medium for crisis communication with the general public (Jin et al., 2014).

After their study of the factors that reflected mistrust in the public comments to the CDC tweets about mask-wearing, Batova (2021) related mixed findings about the effectiveness of social media-based communications from government organizations during health crises. Factors they identified that erode public trust include disagreement among experts, poor coordination, lack of dialogue with the public, reluctance to acknowledge risks, not disclosing information in a timely manner, and neglect of sensitive populations (p. 4).

Researchers who study crisis communication note that trust is a key component of an effective information strategy (Yim & Park, 2019). Public understanding and response to crisis messaging can depend on the audience's perception of trustworthiness (Reynolds & Seeger, 2005), and this is especially true when the public is under stress (Tucker et al., 2008). Unfortunately, the growth of misinformation, especially on social media, erodes the public trust in what information is accurate and which directives should be followed.

In a study of emergency preparedness that included personnel from 223 higher education institutions in the United States, Cheung et al. (2014) found that although 96% of higher education institutional leaders reported having emergency and disaster plans, 10% did not practice the plans, and 20% did not perform after-action reports. Although institutions may have plans in place, they may not have comprehensive strategies that address specific needs, including continuity of operations, emergency information management, and community partnerships (Kapucu & Khosa, 2013).

1.1.3 Twitter use in higher education

Twitter has been the social network of choice for the higher education community, and especially leaders in the field, for at least a decade (Aldahdouh et al., 2020). The hashtag #highered has been the catchall of higher education, followed by three related to online teaching and learning (*#onlinelearning*, *#edtech*, *#mobile learning*) and then *#sachat*, a hashtag often used by student affairs professionals.

Twitter has become a channel within the academic community for communication over research issues (Luo et al., 2020), for professional development and discourse (Gregory & Singh, 2018; Tian et al., 2020), and as a backchannel for communication during academic conferences (Lee et al., 2017). Guzmán Duque and del Moral Pérez (2013) found Twitter was used effectively to improve communication and disseminate institutional information in Latin American universities. More recently, Twitter has been used as a prominent marketing tool for institutions. According to RivalIQ's annual report on the top institutions on social media (Feehan, 2022), trending information includes campus "glamour shots," contests and giveaways designed to increase traffic and engagement, and accomplishments of students, alumni, and other school-related stakeholders.

Jeong and Jalali (2019) found that higher education institutions were increasingly using social media, and Twitter in particular, as a platform of communication with students, faculty, other institutions, and the public. A pre-COVID marketing survey, published by Hootsuite (2019), that included 530 social media users in higher education, identified the foci for social media as communicating with prospective students (77%) and engaging with current students and alumni through advocacy/promotion of sponsored events (94%). A majority (62%) of respondents also indicated that they used social media for crisis communication.

1.2 Theoretical framework

Pearson and Clair (1998) identified an organizational crisis as, "a low-probability, high-impact event that threatens the viability of the organization and is characterized by ambiguity of cause, effect, and means of resolution, as well as by a belief that decisions must be made swiftly" (p. 60). Crandell et al. (2014) highlighted several aspects of this definition, which is widely used in the crisis management literature. Low probability refers to events not perceived as imminent, which leads to less prioritization and contingency planning and contributes to high-damage impact. Ambiguity refers to the unknown effects of a crisis, from the timing of its identification to contingency planning, actions, and reactions. Swift decisions in a crisis often are required, as the failure to act decisively can intensify the crisis and its effects. However, the spread of COVID-19 was anticipated to be a crisis on college campuses (Lu et al., 2021), although the extent was unknown and difficult to predict in early 2020.

Operationally, crises often are addressed in a short-term, reactive perspective. In these events, decision-makers convene to minimize the damage, focusing on effective communications and public relations as much as to address the crisis

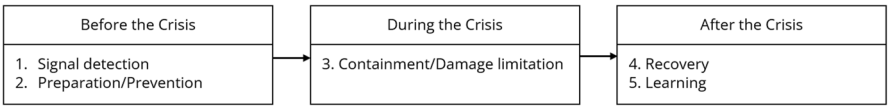

Fig. 1 Expanded crisis management framework (Mitroff, 2005)

(Crandell et al., 2014). A general three-stage framework forms the basis of much of the crisis management approaches. As Crandell et al. (2009) summarized, this includes operations before the crisis, during the crisis, and after the crisis. Pearson and Mitroff (1993) and later Mitroff (2005) expanded this to a 5-stage framework, with a recovery phase completing the cycle (Fig. 1).

In the first phase, signal detection, small indicators or problems begin to emerge. The failure to respond to these initial indicators can result in subsequent problems. Once the crisis is detected, the second phase, crisis preparation, beings when organizations develop a plan by identifying key stakeholders, resources, and actions to deal with the issue. The purpose of the third phase, containment/damage limitation, is to keep a crisis from further spreading or affecting the organization more broadly or in more ways. According to Mitroff (2005), this is also the broadening communications phrase.

Wang and Hutchins (2010) considered lessons learned from the Virginia Tech crisis from a crisis management lens using Mitroff's (2005) framework. Regarding signal detection, the researchers identified administrative failures in noticing multiple precursor signals and reacting quickly to them. In terms of preparation/prevention, the researchers noted ample evidence of inefficiencies in policy and leadership practices in dealing with the event, including lack of awareness, knowledge, and practical experience dealing with a crisis. Wang and Hutchins (2010) also identified a lack of both technological and structural effective communication mechanisms, which evidenced problems with containment and damage limitation. For example, nearly 2 h elapsed from the time of the first shootings to when the campus community was notified about a dangerous situation.

For the purposes of this study, Mitroff's (2005) framework was used alongside social network analysis (Scott, 2017) to identify key influencers and overall discourse at key points during the COVID-19 pandemic crisis. Specifically, the framework was used to contextualize the messengers and messages that were distributed about the pandemic, especially regarding signal detection, preparation/prevention, and to a smaller extent, containment and damage limitation. Although the scope of response is considerably larger than a single campus or organization, the framework is useful in revealing large-scale responses and discourse about actions before and during the crisis.

1.3 Research questions

This study addressed three questions about Twitter discourse and information-sharing in higher education during key early moments in the spread of the coronavirus.

RQ1: What are the social network structures in the #highered Twitter discourse during early periods of the COVID-19 crisis?
RQ2: Who are the key influencers within the #highered network structures during early periods of the COVID-19 crisis?
RQ3: What insights does discourse within the #highered network reveal about information sharing related to the early phases of crisis management?

2 Methodology

2.1 Data sources

Data sources were Twitter posts ("tweets"), both quantitative behavior and discourse, downloaded and analyzed using *NodeXL* (Smith et al., 2010). When people use Twitter, they leave a digital footprint whenever they connect with their contemporaries, and this footprint is typically made up of nodes and linkages. Twitter users are comparable to automobiles, and the tweets that they post are similar to a roadmap. The roadmap data produced are particularly useful for determining the structural patterns of conversation since social network analysis and its accompanying indicators, which will be elaborated in the following section more specifically, measure the connected positions of people who are participating in a conversation as well as the topological flow of messages that are transmitted via tweets.

In the present study, tweets including the hashtag #highered were retrieved for five time points in March and August 2020—M1 (retrieved March 3), M2 (March 17), A1 (August 4), A2 (August 11), and A3 (August 18). The five time points were selected to explore how the use of the hashtag #highered evolved during the early stages of the COVID-19 pandemic. Aligned with the crisis management framework (Mitroff, 2005), the timepoints are from directly before the COVID-19 outbreak (M1, March 3, late signal detection and crisis preparation), when many higher education institutions pivoted to fully virtual learning (M2, March 17, crisis preparation), and during the first 3 weeks of the fall 2020 semester (A1–3, August 4, 11, and 18, containment/damage limitation), which reflect the first three stages of the crisis management framework. Each retrieval covered tweets posted 14 days prior to the retrieval date.

2.2 Data analysis

Social network analysis is a methodology concerned with the importance of relationships among interacting units (Scott, 2017). Researchers identify a data source with connection data to describe patterns among units, to trace the flow of information or resources, and to discover the effects that these associations have on people and organizations. Network data are most commonly converted to matrix form for calculations, and then modeled as sociograms. Some examples of network analysis are connections between researchers using publication citations (Abbas et al., 2019),

links between politicians and constituencies (Lim & Park, 2013), Web site hyperlink behavior as indicators of shared affiliations (Park & Park, 2020), and analysis of friend networks on social media (Park et al., 2019).

In this research, the social network structures of the tweets in the collected Twitter discourse on #highered were analyzed through NodeXL using analytic indicators. Smith et al. (2014) provided a clear description of social network analysis using Twitter data:

> Network maps are created by drawing lines between Twitter users that represent the connections they form when they follow, reply to, or mention one another. Structures emerge in network maps when all the linkages between Twitter users discussing a particular subject are plotted. (p. 5)

The basic elements of a social network are referred to as nodes (or vertices) and edges. In our Twitter discourse data, a node was a tweeter (a person who uploaded a tweet on Twitter), and an edge was a post, or connection, between two tweeters. For examining reciprocal connections between tweeters, *reciprocated vertex pair ratio* and *reciprocated edge ratio* were measured (Social Media Research Foundation, 2021). Total edges, including unique and duplicates, were also calculated. The elements that make up the data and analyses are more fully described in Fig. 2.

One of the ways to determine specific structures in a social network is to classify nodes into groups. Namely, a group consists of nodes, and edges link the nodes within a group. In this sense, a type of group is determined by the type of the nodes in it. For instance, a node can be, but is not limited to, a country (Barnett et al., 2013) or a website (Barnett et al., 2015; Meier, 2016); thus, in those cases, a group becomes a cluster of countries or websites, respectively. In our data, the nodes are tweeters, and the groups are a cluster of tweeters.

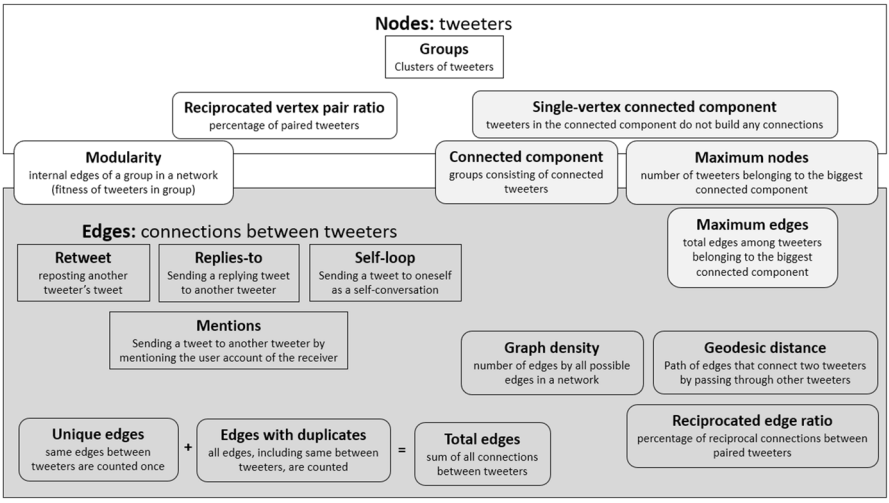

Fig. 2 Elements of Twitter discourse data and analyses

Overall, 636 groups in M1, 545 in M2, 648 in A1, 647 in A2, and 625 in A3 were found in our data. Several indicators were used to identify and analyze the groups. First, connected components were counted. Additionally, single-vertex connected component, maximum nodes in a connected component, maximum edges in a connected component, graph density, and modularity were measured (Fig. 2). The higher the values of graph density and modularity, the more connections are built in a network and in a group, respectively. Also, an average geodesic distance was measured to determine the average path of edges that connect tweeters A and B by passing through other tweeters. The shortest path indicates the smallest number of connections between two tweeters (Social Media Research Foundation, 2021).

To capture topics regarding #highered, we looked at hashtags, word pairs (two words shown together adjacently), and shared URLs that appeared in the collected tweets. These three indicators were examined by frequency to investigate the major content of the topics in the discourse.

Another important metric in network analysis is betweenness centrality. Betweenness centrality indicates "the share of times that a node i needs a node k (whose centrality is being measured) in order to reach a node j via the shortest path" (Borgatti, 2005, p. 60). The higher the betweenness centrality, the more centered a node is in a network. In this study, the influencers with high betweenness centrality were the tweeters who were at the center of the Twitter conversations. In this way, betweenness centrality is used to determine influencers.

2.3 Limitations

There are several noteworthy methodological limitations to our study. Twitter restricts access to the most recent 2 weeks' of tweets using the search API integrated into NodeXL. Additionally, when showing tweets in chronological order, Twitter applies a filtering algorithm to prevent overlapping messages. However, due to numerous technological constraints in collecting Twitter data, we were unable to entirely exclude some possibly overlapping Twitter data when the two collection time points were less than 14 days apart.

Our study captures only five specific time points in March and August 2020. We selected these points because of the alignment with the initial shutdown following the spread of COVID-19, and the beginning of the first fall semester during the pandemic. We also hypothesized these times as directly aligned with the first three phases of Mitroff's model (2005). However, our analysis is limited to these time points and does not address the use of Twitter before or after these periods.

3 Findings

3.1 Social network structures

Table 1 displays descriptive information and key network analysis metrics. More Twitter users posted tweets containing #highered at the August 11 time point (A2)

than at any other point, while the fewest users posted during the March 17 time point (M2). Over the five time periods, the most tweets (2,469) containing the #highered hashtag were posted during the latest time point, A3. However, tweeters posted retweets (4,340 retweets) or replies-to (248 replies) more often in M2. This means new tweets were generated more often in A3, while individuals reposted existing tweets or replied to other tweeters more often in M3. When it comes to the edges, relatively more social connections were built in the earlier phase of the pandemic. Specifically, the most edges (15,189) were generated in A1, with 34.82% being unique edges and 16.79% self-loops. The most reciprocated interactions between tweeters occurred in A1 and M2—0.043 reciprocated vertex pair ratio and 0.083 reciprocated edges ratio.

The structures of the connected components showed that more distinctive groups were found in the latter dates. The most connected components (1,188) and highest maximum nodes in a connected component (3,815) occurred in A2. The most single-vertex connected components (556) were found in A3, while the most maximum edges in a component were seen in M2 (10,411). Similarly, modularity and average geodesic distance were highest in A2 (0.52 modularity; 8.25 average geodesic distance); however, graph density was smallest in A2, which indicates the groups in this period were more distinctively classified compared to other time points.

3.2 Topics

This section includes findings from the discussion topics and the temporal change of topics over time in the discourse of the collected tweets with #highered (Choi et al., 2014). Data sources included frequently used hashtags, words, and URLs in the tweets. As shown in Table 2, in M1, tweets included hashtags related to educational levels (e.g., #college, #highschool), technology, and e-learning. However, many new hashtags emerged in M2: #covid19, #coronavirus, #covid-19, #onlinelearning, and #academictwitter. Most of these hashtags found in M1 and M2 were continuously used in the following period, although only #covid19 of the three COVID-19-related hashtags steadily appeared. The other newly found hashtags were #k12 in A1 and #university in A3, which were regarding educational levels.

Next, word pairs were analyzed to reveal key elements of the discourse taking shape. As shown in Table 3, in M1, the top three word pairs included "higher, education," "learn, more," and "higher, ed." New word pairs about COVID-19, online learning, and textbooks began to appear in M2: "coronavirus, outbreak," "free, access," "during, coronavirus," "access, online," "online, during," "making, higher," "education, textbooks," and "textbooks, html." The range of the topics in A1 was widened to students, faculty, and campus: "students, rarely," "faculty, students," "discuss, faculty," "talk, campuses," and "campuses, tend." The COVID-19-related word pairs "covid, 19" appeared most in A1. In A2, word pairs were concerning, but not limited to, the new semester: "fall, semester," "online, learning," "need, help." In A3, "#highered, needs," "crisis, britain's," and "britain's, universities" were conspicuous.

Table 1 Overview of #highered network structures

	Time points				
	M1	M2	A1	A2	A3
Tweeters	6,402	6,359	6,531	**6,754**	6,377
Tweets	2,469	2,176	2,281	2,432	**5,486**
Retweets (retweet per tweet)	3,656 (1.48)	**4,340 (1.99)**	3,878 (1.70)	3,833 (1.58)	3,957 (0.72)
Replies-to (replies per tweet)	217 (0.09)	**248 (0.11)**	227 (0.10)	198 (0.08)	242 (0.04)
Mention	**3,395**	2,250	3,078	3,249	2,694
Unique edges (% of total)	**5,289 (34.82%)**	4,071 (27.62%)	4,837 (31.95%)	5,098 (33.69%)	4,610 (31.34%)
Edges with duplicates (% of total)	9,900 (65.18%)	**10,671 (72.39%)**	10,304 (68.05%)	10,038 (66.32%)	10,101 (68.66%)
Total (unique & duplicates)	**15,189**	14,742	15,141	15,136	14,711
Self-loops (% of total)	**2,550 (16.79%)**	2,268 (15.39%)	2,367 (15.63%)	2,525 (16.69%)	2,413 (16.40%)
Reciprocated vertex pair ratio	**4.31%**	3.28%	**4.31%**	3.89%	3.89%
Reciprocated edge ratio	**8.26%**	6.35%	**8.26%**	7.48%	7.50%
Connected components	1,095	1,004	1,098	**1,188**	1,125
Single-vertex	516	517	503	434	**556**
Maximum nodes	3,600	3,799	3,536	**3,815**	3,613
Maximum edges	10,339	**10,411**	10,044	10,299	10,216
Average geodesic distance	6.73	7.58	7.39	**8.25**	7.61
Graph density	**19.49**	18.31	18.44	17.40	18.44
Modularity	0.51	0.50	0.51	**0.52**	0.51

Note. The highest value for each indicator over the five time points is in bold

Table 2 Frequency of use of the top Twitter hashtags at all examined time points

Time points				
M1	M2	A1	A2	A3
#highered (5,150)	#highered (4,393)	#highered (5,056)	#highered (4,965)	#highered (4,699)
#edtech (434)	**#covid19 (737)**	#covid19 (486) ↓	#covid19 (410)	#highereducation (424) ↑
#education (404)	**#coronavirus (484)**	#highereducation (355) ↑	#highereducation (374)	#covid19 (423) ↑
#college (335)	#edtech (283) ↓	#edtech (316)	#edtech (326)	#edtech (293) ↓
#highereducation (294)	#college (279) ↓	#college (269)	#education (306) ↑	#education (276)
#edchat (164)	**#onlinelearning (229)**	#education (268) ↑	#college (287) ↑	#college (235)
#elearning (141)	**#academictwitter (194)**	#onlinelearning (210) ↓	#edchat (185) ↑	#onlinelearning (197) ↑
#highschool (134)	**#covid-19 (191)**	#academictwitter (131) ↓	#elearning (177) ↑	#elearning (164)
#collegetalk (125)	#education (175) ↓	#edchat (128) ↓	#academictwitter (170) ↑	**#university** (158)
#ai (103)	#highereducation (147) ↓	**#k12 (120)**	#onlinelearning (166) ↓	#edchat (148) ↓

Note. Hashtags newly emerging over the time points are in bold. Arrows indicate frequency and position trend changes compared to the previous time point

Table 3 Frequency of top Twitter word pairs at each time point

Time points				
M1	M2	A1	A2	A3
higher, education (332)	higher, education (408)	**covid, 19** (220)	higher, education (329)	#highered, #highereducation (210) ↑
#highered, #highereducation (147)	**coronavirus, outbreak** (341)	higher, education (208) ↓	covid, 19 (284) ↑	covid, 19 (191)
#highered, #edtech (119)	**free, access** (317)	**building, work** (174)	#highered, #highereducation (197) ↑	higher, education (190) ↓
#college, #collegetalk (117)	**during, coronavirus** (311)	#highered, #highereducation (160) ↑	**#highered, institutions** (100)	**#highered, needs** (120)
learn, more (98)	**access, online** (309)	**work, #highered** (132)	learn, more (97) ↓	**well, put** (118)
higher, ed (95)	**online, during** (308)	**students, rarely** (127)	higher, ed (94) ↓	**put, seat** (118)
#edtech, #highered (91)	**making, higher** (302)	**faculty, students** (126)	**fall, semester** (86)	**seat, belt** (118)
#education, #highered (91)	**education, textbooks** (302)	**discuss, faculty** (123)	**online, learning** (85)	**belt, crisis** (118)
luminafound, sharing (91)	**textbooks, html** (302)	**talk, campuses** (122)	**need, help** (80)	**crisis, britain's** (118)
sharing, equity (91)	**html, format** (302)	**campuses, tend** (122)	#college, #collegetalk (78) ↓	**britain's, universities** (118)

Note. Word pairs newly emerging over the time points are in bold. Arrows indicate frequency and position trend changes compared to the previous time point

The frequently shared URLs showed the types of online resources and content that tweeters were interested over the period (Table 4). In M1, a journal article about artificial intelligence in education (Con la tecnología de Blogger, 2020a) was the most frequently shared. In M2, news and blog posts regarding the influence of COVID-19 in education were getting attention. The shared URLs conveyed information about cancellation of the SAT due to COVID-19 (Camera, 2020; College Board, 2020), moving to online teaching and learning and possible associated difficulty (Carapezza, 2020; Klein, 2020; Weller, 2020a), and useful resources for teaching online (Weller, 2020b).

In A1, the link to Blackboard, one of the most widely used learning management systems, was frequently shared. Also, financial issues for schools and students became a major discussion focus (Block & Ermey, 2020; Hess, 2020; Yale, 2020). The conversation on financial issues at schools continued in A2 (D'Amato, 2020; McGurran, 2020). Aligned with this conversation, students' entrance into schools and enrollment at K-12 and colleges was prominent (Castonguay, 2020; Victory, 2020). In addition, an article appeared on the top list about improving cybersecurity of higher education networks by employing machine learning (Moore, 2020). Issues related to finance and college admissions (Kerr, 2020; Smith, 2020) were still often shared. Furthermore, there were tensions and concerns of faculty members and students about school opening for the new semester in fall 2020 (Associated Press, 2020; Jaschik, 2020; Whiteford, 2020). Tweeters also shared useful resources for teaching and learning, especially remotely (Blackboard, 2020; Lewis, 2020; Retrieval Practice, 2018; The Chronicle of Higher Education, 2020).

3.3 Groups

Visualized networks of the groups of the nodes (tweeters) are shown in Fig. 3. In addition, the top groups by the number of tweeters and the frequently used, emergent hashtags in the groups are presented in Supplemental Information. In the visualized networks, G1 (Group 1) in each time point has the most tweeters, and the tweeters are connected via edges as they send and receive tweets during conversations (Fig. 3).

Several notable discussions emerged in the group analysis. In M1, equity in education was discussed. Compared to the discussion topics in M1, tweeters in M2 increasingly talked about COVID-19 and the transition to remote teaching (Fig. 4). Tweeters in G2 had the most conversations, as 1,688 edges were generated. This finding shows the remote and online learning was getting higher attention in this period due to COVID-19.

In A1, the largest volume of conversations happened in G2 where e-learning in higher education and K-12 due to COVID-19 and pedagogy were continuously discussed. Other new hashtags emerged in relation to educational technology, equity issues, school opening, and admissions (Fig. 4). Next, in A2, frequent conversations about a new topic occurred in G2: machine learning. Other emergent hashtags concerned data science, open access publishing, reflection, economy, wellbeing, writing

Table 4 Frequently shared URLs (see full citation listing in supplemental information)

Time points				
M1	M2	A1	A2	A3
E-learning, conocimiento en red (Con la tecnología de Blogger, 2020a)	College board cancels May SAT in response to the coronavirus (College Board, 2020)	Blackboard (Blackboard Inc., n.d.)	Outstanding teaching… (Advance HE, 2020)	[a]Colleges giving tuition discounts this spring (Kerr, 2020)
National center for the study… (Hunter, 2020)	The COVID-19 online pivot… (Weller, 2020a)	ACT is struggling… (Adams, 2020)	Overwhelmed by intrusions (Moore, 2020)	August waves of campus… (Whiteford, 2020)
My dissertation coach (My dissertation coach, 2020)	Coronavirus forces hundreds of sites… (Camera, 2020)	How to appeal college financial aid decisions… (Yale, 2020)	Advantages of community colleges… (Castonguay, 2020)	Choosing the right final year research… (Lewis, 2020)
Med school after 40 (Boyle, 2020)	The COVID-19 online pivot… (Weller, 2020b)	It's time to stem malpractice in STEM admissions (Sternberg, 2020)	Search your school…(D'Amato, 2020)	7 helpful online learning resources for fall (Blackboard, 2020)
A growing list of US colleges are… (Guzman & Sutton, 2020, February 28)	Budget cuts series 2021: Billions from student loan programs (Smart Dissent, 2020)	What we know about coronavirus cases on campus (Cai et al., 2020)	High school seniors struggle with registration problems… (Victory, 2020)	How the coronavirus has upended college admissions (Smith, 2020)
Meeting the 2020 higher education advisory council (Salesforce.org, 2020)	STLHE SAPES (Society for Teaching and Learning in Higher Education, 2021)	WPCampus 2020 Online (WPCampus, n.d.)	Top personal finance experts offer tips… (McGurran, 2020)	Boston University faculty protest reopening plan (Associated Press, 2020)
[b]US higher education technology conference calendar (2020)	I will survive… (Bruening, 2020)	Survey: Student opinions on transfer credit (Amour, 2020)	The ADA at 30 (Burke, 2020)	The hardest college… (Harrington, 2020)
Despite what you hear, college pays off (Newton, 2020)	Covid-19 Uni Status UK (2020)	The top 50 U.S. colleges… (Hess, 2020)	How to write a syllabus (Gonzalez, 2016)	Nervous freshmen, nervous colleges (Jaschik, 2020)
IvyWise mailing list (IvyWise, 2020)	What 'distance learning' looks like…(Klein, 2020)	How COVID-19 is changing the way…(Block & Ermey, 2020)	Covid tests and quarantines… (Hartocollis & Hubler, 2020)	Weekly teaching tips (Retrieval Practice, 2018)
Policing the American university (Knowles, 2020)	'Organized chaos'… (Carapezza, 2020)	E-learning, conocimiento en red (Con la tecnología de Blogger, 2020b)	Learning Revolution (Hargadon, n.d.)	[c]When students see you on screen this fall… (*Chronicle of Higher Education*, 2020)

Note. [a]link updated with newest information for 2021 spring on December 9, 2020; [b]link no longer available; [c]link to a tweet

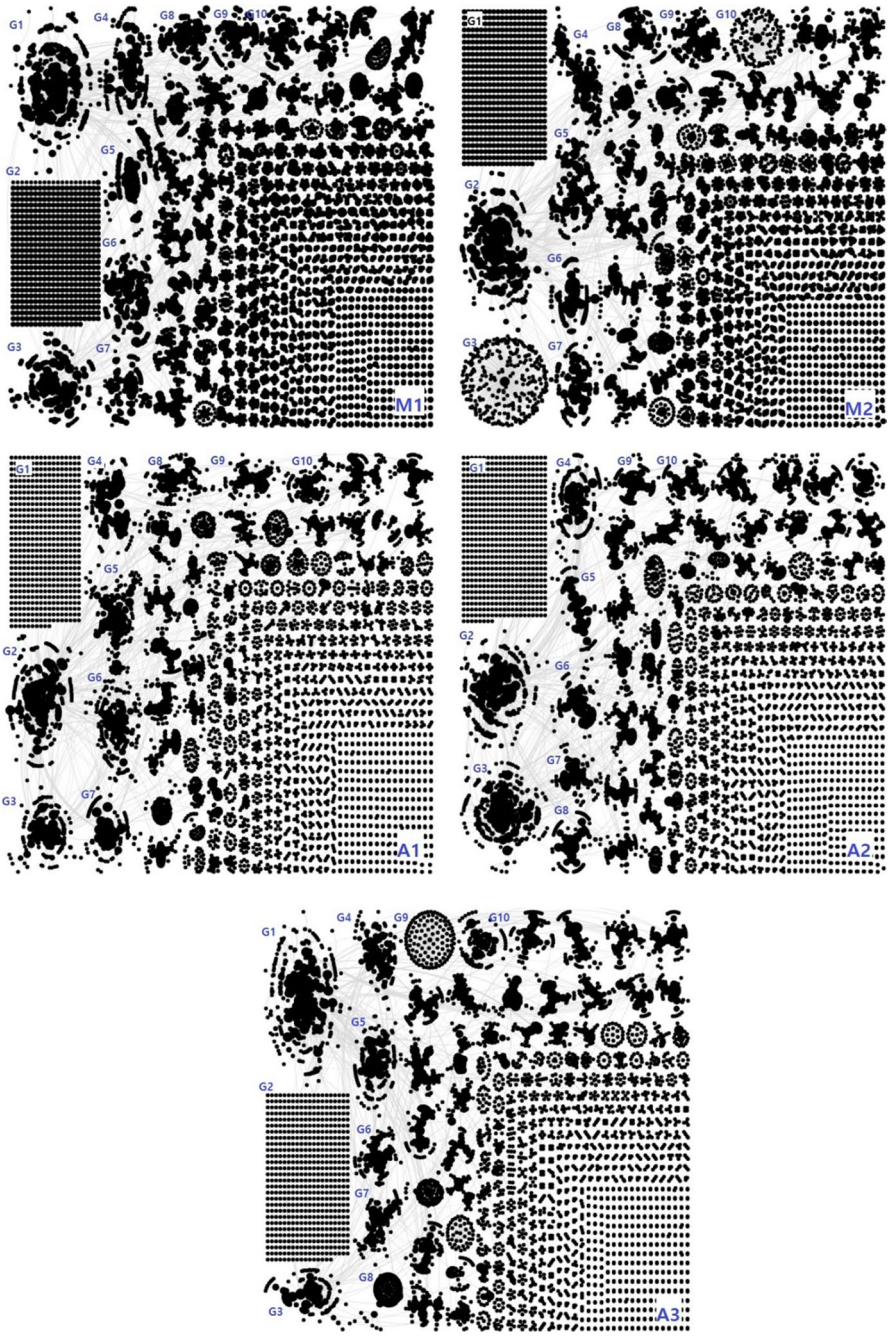

Fig. 3 Visualized networks of groups (G) of Tweeters over time points (M and A). (See supplemental information for frequently used and emergent hashtags over time and links to more extensive and full-color visualizations)

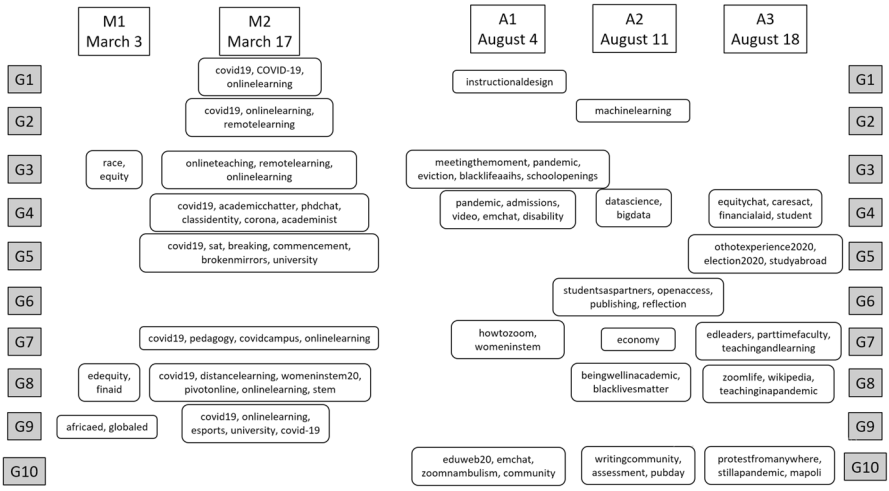

Fig. 4 Higher education Twitter hashtag discussions that emerged in group analysis

communities, and assessment. Lastly, in A3, the dominant conversation was still about online learning and COVID-19 in G1. In addition, equity and finance were still top issues in G4. Further, other new topics emerged about the 2020 election, online platforms for higher education, and study abroad in G5; educational leadership, part-time faculty, and teaching and learning in G7; using Zoom and teaching in a pandemic in G8; and politics, protests, and the lasting pandemic in G10 (Fig. 4).

3.4 Influencers

In general, influential Twitter accounts that had high betweenness centrality were related to institutes or organizations in higher education and technology. Individual experts in a wider range of areas were also getting high attention over the time spans (Table 5). For instance, in M1, influential accounts included @edubot_he, @educause, @higheredsurge, @insidehighered, and @chronicle, which shared news and articles about higher education. In M2, an individual's account (@katgallow) received the highest betweenness centrality. This tweeter was teaching law and shared a link to a resource for helping instructors move to remote teaching due to COVID-19. Other educational experts (@ laurapasquini, @joshua_r_eyler, @karenraycosta) were also in the center of the conversation.

In A1, a professional's account (@jc_james_clark) had high betweenness centrality, likely because the company where he worked provided data for nationwide K-12 schools. Other new influential accounts were a magazine in educational technology (@edtech_highered) and a professor in areas of education, sociology, and medicine (@saragoldrickrab), who posted tweets about college students' financial issues. In A2, the accounts for the *Higher Education Research & Development* journal (@herdjournal) and researchers and faculty members (@tjlogan, @morgansetdesign, @merlinotello) were centered in the conversation. In A3, other individuals such as

Table 5 Twitter accounts with the highest betweenness centralities at each time point

Time points				
M1	M2	A1	A2	A3
luminafound (2,606,614.72)	**katgallow** (2,323,326.29)	insidehighered (3,483,754.15)	insidehighered (3,201,551.78)	insidehighered (1,861,108.31)
cmdatascoop (2,473,354.26)	**cupacademic** (2,185,735.55)	**jselingo** (2,373,695.39)	***edubot_he*** (2,317,101.12)	***cmdatascoop*** (1,756,236.97)
edubot_he (1,813,605.36)	***edubot_he*** (2,180,280.98)	***cmdatascoop*** (1,584,119.78)	***cmdatascoop*** (1,798,876.45)	**fred_highered** (1,706,252.77)
educause (1,367,395.81)	educause (2,069,898.62)	**jc_james_clark** (1,426,701.13)	**tjlogan** (1,765,403.38)	academicchatter (1,677,488.60)
higheredsurge (1,286,313.86)	***cmdatascoop*** (2,063,998.61)	karenraycosta (1,286,588.45)	edtech_highered (1,677,438.98)	**edexcelencia** (1,589,608.72)
jaspermackay (1,227,554.42)	chronicle (1,588,704.13)	**fmfrancoise** (1,067,388.99)	**herdjournal** (1,670,653.24)	***edubot_he*** (1,582,925.98)
insidehighered (1,200,480.30)	**laurapasquini** (1,552,421.84)	**edtech_highered** (1,048,405.23)	**morgansetdesign** (1,523,230.02)	**docrobphd23** (1,533,078.37)
chronicle (982,949.34)	**academicchatter** (1,391,699.73)	***edubot_he*** (1,007,974.43)	**merlinotello** (1,498,466.02)	**eraser** (1,525,035.31)
highered_cb (978,362.00)	**joshua_r_eyler** (1,356,694.93)	luminafound (1,002,685.63)	**wustl** (1,477,211.02)	**profgabrielle** (1,126,706.89)
csuci (903,718.51)	**karenraycosta** (1,193,717.84)	**saragoldrickrab** (912,081.03)	**landryst** (1,356,897.60)	chronicle (1,118,035.83)

Note. Twitter accounts newly emerging over the time points are in bold, and those continuously appearing throughout the period are in bold and italics. Betweenness centrality values of the Twitter accounts are indicated in parentheses

an expert in educational technology (@fred_highered) and a professor in psychology and public health (@docrobphd23) newly joined the top list of accounts with high betweenness centrality.

4 Discussion and considerations

4.1 Crisis management as reflected on Twitter

Twitter users used the hashtag #highered widely in the early stages of the COVID-19 pandemic. Conversation on Twitter rapidly evolved, as did the prominent influencers using #highered. Prior to the first group analysis (M1, retrieved on March 3, 2020), conversation on Twitter revolved around educational technology, likely driven by the Lumina Foundation's recent announcement that racial equity would be a focus of their impact venture investments, which includes several prominent educational technology companies (Lumina Foundation, 2021). This is reflective of the signal detection phase (Mitroff, 2005), as news and information about COVID-19 on campus was just emerging. Influencers during M1 included relatively well-known higher education news sources (i.e. *Chronicle of Higher Education, EdSurge, Inside Higher Education,* and *EduCause*). Frequently shared URLs during this timeframe had little in common, ranging from an article on dissertation writing, an article about attending medical school as a 40-year-old, and an article discussion policing in American universities, among others. The only mention of COVID-19 during this timeframe was a frequently shared article on the potential cancellation of study abroad programs in the United States due to the virus.

A prominent finding of this study is how the use of #highered and discourse on Twitter rapidly changed during the second group analysis (M2, March 17), which signifies a shift to the second phase of Mitroff's (2005) crisis management framework: crisis preparation. This preparation was likely accelerated due to underestimates of the spread and severity of the virus. Conversation on Twitter during this grouping was almost entirely centered on the pandemic and the implications of the sudden shift to online learning. Influencers also shifted to more individual accounts rather than well-known news sources found in M1. Professors and educational experts shared resources for effectively teaching remotely, tips for accessing textbooks online, and the implications of online learning. Frequently shared URLs also centered solely on COVID-19, with topics including budget cuts due to the pandemic, the cancellation of the SAT, a student's perspective on the pivot to online education, and distance learning for students without access to computers. As the pandemic continued, so did the use of Twitter and #highered to discuss COVID-19 and its effect on universities, students, faculty, and staff.

The 3rd–5th time points we analyzed (A1, August 4; A2, August 11; A3, August 18) revealed conversations centered on university fall opening plans and the widespread use of remote learning. We anticipated posts that would be related to containment/damage limitation (Mitroff, 2005), such as reassurances of safe campuses and various protocols to curb the spread and potential additional outbreaks. While these posts were present, we observed a larger than anticipated concentration group of

posts again reflecting a crisis preparation phase. Interestingly, prominent influencers during these timeframes remained predominantly faculty and educational experts rather than well-known news outlets. However, emerging and new influencers were common during all three time points (8 in M2, 7 in A1, 8 in A2, and 7 in A3, versus 2 in M1).

4.2 Key influencers as sources of information

While the topics discussed via Twitter remained consistent during the pandemic, the individuals central to the conversations were consistently changing. Twitter was a source of news and information for the higher education community. However, drivers of information seemingly transitioned from well-known news outlets prior to the pandemic (i.e. *Chronicle of Higher Education, EdSurge, Inside Higher Education,* and *EduCause*) to individuals directly experiencing the pandemic and its impact on higher education. Indeed, past research exploring the topics of climate change and internet governance found that high attention actors received more traction via social media during times of high interest (Stier et al., 2018). Our work expands previous research and shows that higher education as a field operated similarly to political topics during a time of crisis on social media.

A remaining question beyond the scope of our analysis is the validity of information and resources shared by individuals during key decision points of the pandemic, and whether the emergent influencers impacted policy decisions at the institutional and state levels of higher education. Unlike well-known and effectively operated news sources, individuals and even educational experts are not required to fact check their social media posts. During times of crisis, the need for updated information often can supersede verification of its veracity, and there may be an increase in the spread of disinformation (Park et al., 2020). Future research on social network platforms and their use during times of crisis should explore the effect of the crisis on who becomes key sources of information in higher education, if individual influencers are sharing verified and reliable information, and whether higher education as an industry is susceptible to the growing spread of disinformation through social media when formulating policy.

4.3 Social media as crisis management

There is little evidence from our study indicating whether higher education leaders used Twitter as a tool for crisis communication during the early stages of the pandemic, if their communication via social media was impactful, or if social media influenced decision making. While higher education institutions increasingly use social media as a platform for communication (Jeong & Jalali, 2019), our findings show that it was often the faculty they employ who had the farthest reach on Twitter. Emerging research on crisis management in higher education points to the potential impact of social media and prominent influencers on the application. For example, Liu et al., (2021b) found that among higher education administrators in their study, "social media may have been instrumental in gathering publics'

concerns…detect[ing] concerns… [and] track[ing] and manag[ing] COVID-19 misinformation" (p. 469). Our study complements this work by revealing how networks evolved in the early stages of crisis management during the pandemic (signal detection and preparation/prevention), what information was shared most often, and who emerged as the key influencers that administrators may turn to when seeking information via social media. Wang and Hutchins (2010) identified a need for developing crisis leaders and for facilitating crisis communication as key opportunities for improving crisis management practice. These opportunities were also reflected in the findings of this study, especially as conversations reflected an emerging third phase of containment/damage limitation in August 2020.

5 Future research and conclusion

The use of #highered within Twitter discourse changed during the M2 (March 17) time period, signifying a rapid shift to crisis preparation that was likely due to underestimates of virus spread and severity (Mitroff, 2005). Conversations were almost entirely focused on the pandemic and the sudden shift to online learning. Influencers shifted to more individual accounts, such as professors and educational experts, rather than well-known news sources found in M1. Frequently shared resources and URLs were focused on effective remote teaching, ways to access online textbooks, potential effects of online learning, budget cuts resulting from the pandemic, SAT cancellation, and equity in distance learning. As the pandemic continued, Twitter conversations centered on fall 2020 opening plans and the use of remote teaching rather than on containment/damage limitation (Mitroff, 2005), such as reassurances of safe campuses and various protocols to curb the spread and potential additional outbreaks. While posts about containment and damage limitation existed, posts again largely reflected a crisis preparation phase. Our work expands previous social media research and suggests that higher education functioned similarly to politics during a time of crisis.

Further research should consider #highered and #COVID during the same August dates in 2021 to identify additional aspects of the containment/damage limitation and the beginning of the recovery phases, and again in August 2022 to consider additional recovery and learning, once data become available. According to Mitroff (2005), the fourth phase, recovery, is when organizations enact procedures to resume normal business activities. This should ideally be followed by the fifth phase, learning, that involves reflection on the experience and institutional response to create future plans and crisis management practices and a final phase for redesign, where knowledge from the learning phase is used to create change and restructure the crisis management system. Aside from the Virginia Tech shooting (Wang & Hutchins, 2010), few if any, studies have examined full cycle crisis management approaches in higher education. A holistic study could inform the creation of a crisis management team that "can enact these capabilities with speed and efficiency during a crisis and can learn from the experience how to improve the system" (Mitroff et al., 2006, p. 62).

The COVID-19 pandemic was unique in its longevity and the lack of clear solutions for universities. Emerging scholarship points to universities failing to provide the appropriate resources, both academic and social, for faculty, staff, and students to succeed during the pandemic (Collom & Cooper, 2022; Mutinda & Liu, 2021). Therefore, an additional area of interest for future research would be to examine Twitter discourse with a focus on the psychological aspects for higher education faculty, staff, and students. Nonetheless, possibilities in front of universities illuminate the transformation of teaching and learning into higher flexibility and adaptation to this radically changing environment (Green, 2020), which can be accomplished through educators' efforts to convert this challenge into a pedagogical opportunity (Leask, 2020). As Pearson and Clair (1998) noted, "Organizational crisis management effectiveness is evidenced when potential crises are averted or when key stakeholders believe that the success outcomes of short- and long-range impacts of crises outweigh the failure outcomes" (p. 61). University administrators may have helped bridge the communication gap between faculty, staff, students, and universities by more purposeful sharing via social media their response to the crisis, resources available to support those in need, and why they made certain decisions for their institution.

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Data availability The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

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