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Crisis in a Networked World

Features of Computer-Mediated Communication in the April 16, 2007, Virginia Tech Event

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Crises and disasters have micro and macro social arrangements that differ from routine situations, as the field of disaster studies has described over its 100-year history. With increasingly pervasive information and communications technology and a changing political arena where terrorism is perceived as a major threat, the attention to crisis is high. Some of these new features of social life have created changes in disaster response that we are only beginning to understand. The University of Colorado is establishing an area of sociologically informed research and information and communications technology development in *crisis informatics*. This article reports on research that examines features of computer-mediated communication and information sharing activity during and after the April 16, 2007, crisis at Virginia Tech by members of the public. The authors consider consequences that these technology-supported social interactions have on emergency response and implications for methods in e-Social Science.

Keywords: *computer-mediated communication (CMC); computer-supported cooperative work (CSCW); crisis informatics; emergency response; information and communication technology; peer communication; social media; Web 2.0; widescale interaction*

Introduction: The Widening Arena of Emergency Response

Throughout history, people have demonstrated resilience through adversity by actively participating in the response and recovery efforts of the disasters that affect them. They do so through the innovation and adaptation of skills and at-hand resources (Kendra, Wachtendorf, & Quarantelli, 2003; Tierney, Lindell, & Perry, 2001) including, more recently, information and communication technology (ICT; Mark & Semaan, 2008). In addition, members of the public use peer-generated information in tandem with official information they receive about an ensuing event. Social science research on risk communication behavior predating wide ICT diffusion shows that members of the public use a range of information sources to make decisions in disaster events that include friends, family, and neighbors (Mileti et al., 2006; Sorensen, 2000; Sorenson & Sorenson, 2006).

In recent years, ICT has not only made the information seeking and self-organizing behaviors of the public more noticeable, it has also expanded it to much larger scales of social interaction and has moved patterns of communication from the ephemeral to the traceable. This newly expanded arena for disaster response is setting the stage for new social arrangements at all levels of social organization. ICTs that support peer-to-peer communication—and specifically "social media" or "Web 2.0" applications such as social networking applications like Facebook, Flickr, MySpace, and messaging services like Twitter—serve as a new means for disaster survivors, curious onlookers, and compassionate helpers to find information and to assist others (Hagar & Haythornthwaite, 2005; Hughes, Palen, Sutton, Liu, & Vieweg, 2008; Liu, Palen, Sutton, Hughes, & Vieweg, 2008; Palen & Liu, 2007; Palen & Vieweg, 2008; Schneider & Foot, 2004). In today's networked world, members of the public increasingly rely on peer-distributed information, often finding it to be more timely and accurate. In events that are spatially diffuse (like hurricanes) and protracted (like wildfires), sources of information from multiple eyes-on-the-ground can be more helpful than official news sources because the information can provide a more local context and rapid updates for those who need to make decisions about how to act (Shklovski, Palen, & Sutton, 2008; Sutton, Palen, & Shlovski, 2008; Vieweg, Palen, Liu, Hughes, & Sutton, 2008). In addition, social media services provide new ways for people to interact both within and outside the spatial bounds of the crisis event, though of course the extent to which they can do this is dependent on the status of the technological communications infrastructure.

However, at this point in time, the degree to which this kind of peer-to-peer communication of crisis information is used relative to official sources is not readily quantitatively measurable in large part because of the rapidity of change in practice over each event and because of the diffuse nature of information dissemination itself. Instead, our research program has focused on identifying features of computer-mediated communication (CMC)–enabled information sharing after a series of events, with the study of the 2007 Virginia Tech (VT) shootings as the first. Our first-line objective is to describe features of sociotechnical change in emergency response by members of the public to better anticipate and inform future directions for innovation and policy change. The matter of how such ICT-supported communications will move from the unofficial "backchannel" to something more formally incorporated in the organization of emergency management is a primary concern.

Authors' Note: We extend deep sympathy to the families and friends of the victims of the VT tragedy, and to the VT community. The authors are appreciative of the students, staff, and faculty of VT for their thoughtful participation during an exceptionally difficult time. We thank Deborah Tatar, Steve Harrison, Scott McCrickard, Colleen Mihal, Kwame Harrison, Dennis Kafura, and others for their logistical assistance in conducting this research. We thank our colleagues Jeannette Sutton and Kathleen Tierney of the Natural Hazards Center at the University of Colorado for participation in previous presentations of this work, as well as Morten Kyng and Margit Kristensen of the University of Aarhus, Denmark, for discussions about collaboration in crisis that are reflected in our thinking here. We thank anonymous reviewers whose critiques have improved presentation and analysis. This research is supported by the National Science Foundation (but does not reflect the opinion of NSF) through IIS-0546315 and a Graduate Fellowship (Liu).

Challenges Facing e-Social Science and Disaster Studies

A critical challenge, however, remains in how to study this phenomenon of rapid societal change, both in terms of sampling and selecting units of analysis. The nearly 100-year long history of sociological study of disaster has been built on the investigation of a wide range of social phenomenon during pre- and post-phases of natural, human-induced, and technological hazard events (Perry, 2006). Disaster researchers adapt empirical methods—largely qualitative—to capture what are known as *perishable data* before features of the social phenomena that arise in the nonroutine situations disappear. Known as *quick response research* (QRR), disaster social scientists deploy to disaster sites to conduct direct observation and face-to-face interviews, gather field documents, and capture images (see for instance, Quarantelli, 2002). With the capabilities of pervasive ICT, additional methodological complexities arise in this space. Crisis situations have inherently strong geographical features, but opportunities for virtual participation are now wider and support even more rapid social convergence. As such, disaster and information science researchers alike are newly struggling with how to rigorously account for social phenomena on-site as well as on-line, because those short-lived, nonroutine activities are increasingly simultaneous and intertwined.

These same difficult problems can be found throughout the budding e-Social Science field as we collectively struggle to resolve issues and challenges in the collection, integration, and sharing of large data sets for analysis. That this requires innovation for data capture of social activity during (so-called) routine situations hints at the additional concerns we face when trying to capture activity under nonroutine, emergent, and urgent conditions where information production is intensified and time frames are compressed.

In addition, just at a time when the interest in ICT and disasters from many sectors is high, disaster research activities tend to be conservative and caution against the investigation of the virtual as a substitute for on-site investigation (Stallings, 2006); the field of disaster studies was, after all, born out of the need to empirically correct the inaccurate and sensational media reporting of disaster-related behavior. However, the nature of emergency response is fundamentally changing such that the study of the virtual should not merely be framed as a window onto the physical. The virtual is an arena of interaction in crisis response that gives rise to new social structures and activities that need their own analytical attention.

Crisis Informatics Perspective

It is these concerns and interests that motivate the development of an area of work called *crisis informatics* (Hagar, 2006) to address an increasing number of considerations that need to be incorporated into both the scholarly and the practical approaches to emergency response. Crisis informatics extends consideration of emergency response to not only include official responders (who tend to be the focus in policy and technology matters) but also members of the public. Therefore, crisis informatics views emergency response as an expanded social system where information is disseminated within and between official and public channels and entities. Crisis informatics wrestles with methodological concerns as it

strives to develop new theory and support sociologically informed development of both ICT and policy.

This article reports on the results of an investigation of CMC by members of the public that occurred in the aftermath of the April 16, 2007, VT shooting in Blacksburg, Virginia, where a single shooter killed 32 people and injured many more over the course of an approximately two-and-a-half hour time period in two buildings on the university campus. Our overarching objective is to describe the extended ICT-enabled social arena that arises in reaction to crisis events through the analysis of peer-to-peer communications from data gathered in both the field and the online. We attempt to account for and describe some of the central public-side information sharing activities following this crisis and consider how they relate to existing descriptions of geographically bound post-event behavior. In the next sections, we describe our methods and their evolution for studying this crisis event and report on findings from the multisited investigation.

Studying the Emergency at VT

The analytical task of understanding the constantly changing social relations that accompany crisis is enormous. This study, which was the first of this scope for our lab, required that we formulate *how* to study CMC in crisis as we studied it, even though we had methodological starting points from the disaster studies literature on which to rely (Stallings, 2002). The challenge here was knowing "where to look." This is not an unfamiliar experience in ethnographically based work and is often inherent to the process. Researching crisis in today's networked world is helped by employing a multisited approach for collecting data on-site and on-line. For this study, we went to the physical site to collect specific kinds of data, and then subsequently engaged in more extensive post hoc data collection on social media activity. As we explain below, the subsequent online ethnographically motivated work was guided and constrained by directions first suggested by the data collected on-site.

Methodological Approach and Data Representations

Our work began within hours of the media reports of a shooting on the VT campus located in Blacksburg, Virginia. The shootings occurred on Monday morning, April 16, 2007; our team began monitoring official and unofficial news releases later that day. One of the first news releases on CNN.com mentioned students posting information to a Web site while in their journalism class as the crisis unfolded. This report piqued our interest about the forms of communication that might be used to support information generation, seeking, and sharing in this university campus-situated event.

The methodological approach to these still open research questions about the immediate CMC in the event's aftermath was to monitor on-line activity as well as conduct on-site QRR. Although we could not fully understand the entire space of concerns around these communications at that time, we suspected that the on-site crisis communications between students and others in the physical space of the event would have important relationships to what was happening on-line. We contacted faculty colleagues at VT to assess accessibility

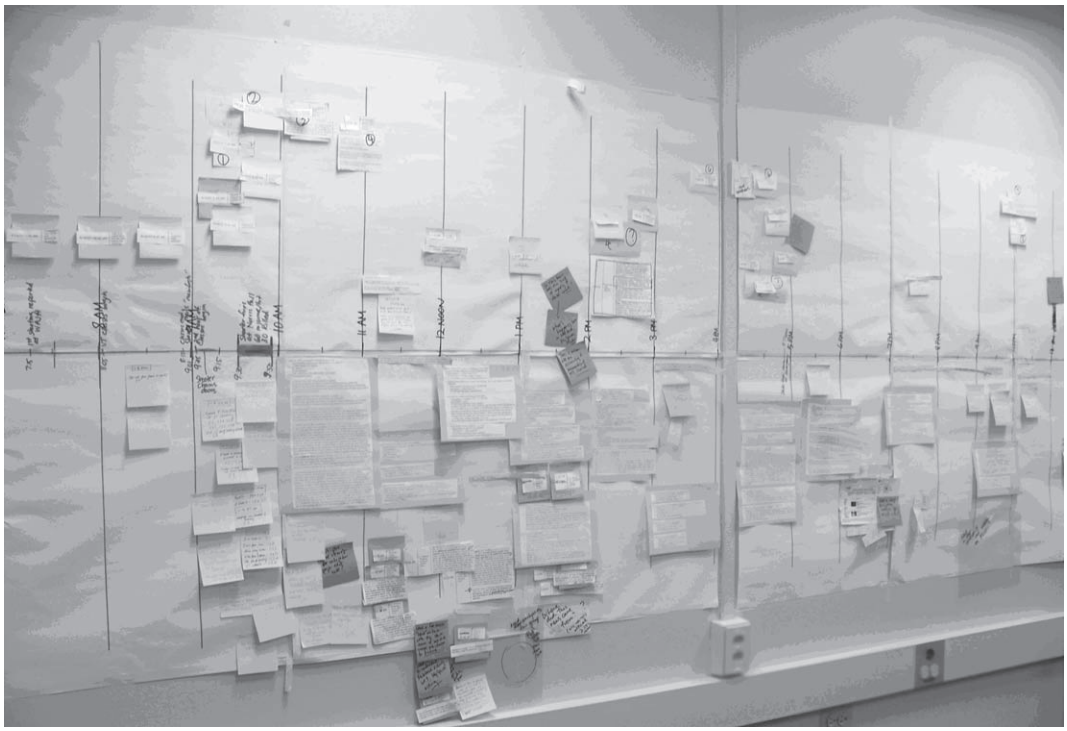
and to generate an initial sample of interviewees. Two team members went to Blacksburg 5 days after the shooting (from Saturday, April 21 to Wednesday, April 25) to conduct face-to-face interviews one-on-one, in small groups and in classroom groups, and collect documents and artifacts including digital photos of public gatherings and other memorialization activities. A standing human participants protocol preapproved for crisis events and modified to this particular situation expedited logistics.

During this time, the campus (which closed following the shootings) had reopened to students, and a number of memorializing events were taking place. The team conducted a total of 56 face-to-face interviews with students, faculty, and staff from the VT campus as well as community members in Blacksburg. Interviewees were selected as a result of convenience sampling; they were approached in public spaces and interviewed only when they expressed willingness to talk about their experiences. In addition, one researcher visited a campus sorority house with which she had connections and both researchers visited classes at the invitation of our faculty colleagues. Interview questions focused on how students were first made aware of the shootings, what they did once they were cognizant, and how they stayed updated about its changing status throughout that first day. Because convenience samples are not representative of the larger populations to which they might belong, this analysis only describes the actions and views of our interviewees. In addition, we documented critical campus-initiated communications. Together, we used the data to sketch out high-level descriptions of behaviors as they related to official news releases. These data also supported the line of inquiry for the subsequent on-line data collection.

While our two researchers were in Blacksburg, Virginia, the rest of the research team members continued to remotely monitor newsfeeds and began to investigate, at a high level, a number of social media sites (including Flickr, English language Wikipedia, Facebook, Myspace, Orkut, Second Life). Once our team members returned from the field, we put into place a more systematic process for collecting on-line interactions. For example, the unwieldy Facebook had more than 500 groups that included the VT shooting as its topic. We considered each of these and examined 50 of these groups based on features that seemed significant: notable membership size, exchanges that centered on people's well-being such as "I'm OK" and "Are you OK" types of messages (given the results of the on-site data collection), groups that were started on April 16 with extended activity, and groups that had notable connections to other on-line forums (petitions, e.g.) or to the physical space of campus (such as an existing group created for incoming VT students). Additionally, we set criteria to exclude groups focused on memorializing; this is not because memorialization activity is not important but rather because such activity was abundant and already happening in the groups that we had retained for further study.

The decision to archive sites was iterative. As we discovered more pointers to forums, we archived them. Although we discriminated where and when we could, we archived sites even if we were not sure whether they would prove significant in our research; our reasoning was to collect these data before it disappeared. Later, a sampling of the forums we archived became the focus of more intensive ethnographically informed research, once we built a high-level understanding of the activities that had taken place. The VT research was our first experience with this scale of rapid and wide-reaching data collection. Our approach was to check interpretations against disaster studies research to help explain the kind of information traced across different people, forums, and places. This project has

Figure 1
Data Visualized by Timeline on April 16, 2007

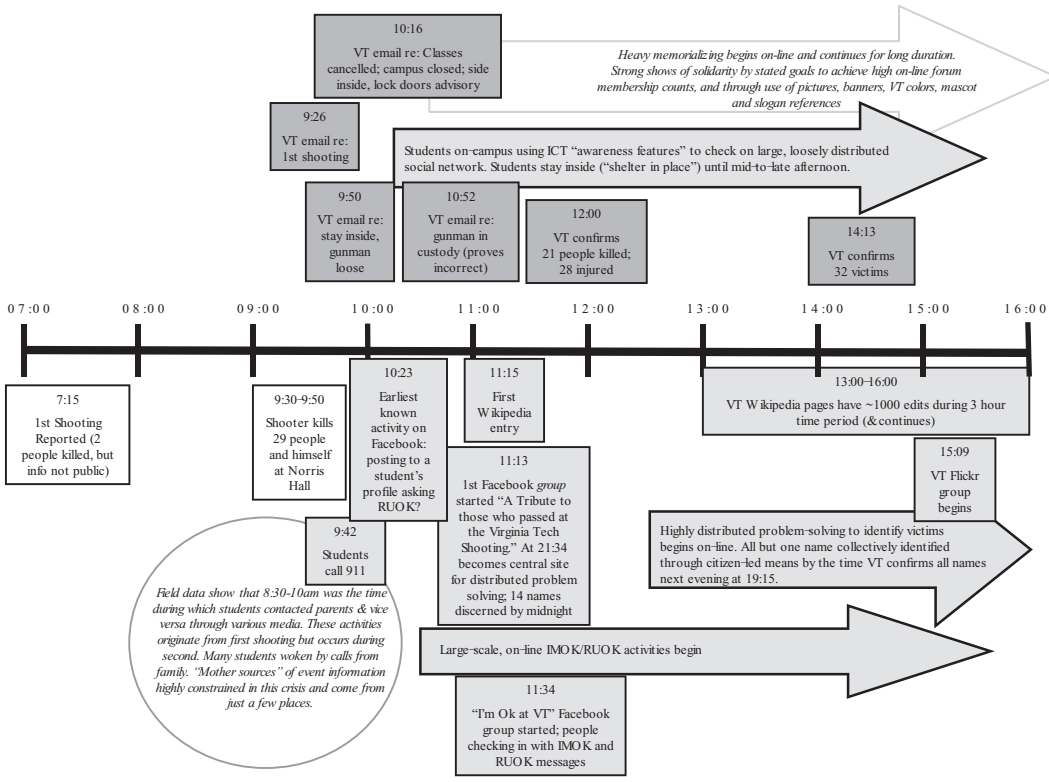


served as a reference point for how to collect and store data for current and future projects, because we are now able to limit the scope of our current inquiries to more specific issues and sites of interaction that made themselves apparent in this research.

Figure 1 shows the central analytical workspace—a detailed timeline of the first 2 days of the crisis that depicts critical events—these events include (but are not limited to) when the shootings occurred, when information was released, when "Are you ok?" activities occurred, and other pertinent and significant activities. The total timeline stretches over 25 feet on our lab wall. As accurately as possible—usually down to the minute—we populated the timeline with data that pinpoint public-side communications ("informal" communications) against official communications (university e-mail, web postings, press conferences; also known as "formal" communications) from data collected across many sites of interaction. Whereas in the beginning of the process an entire social networking site might be a site for investigation, as we discuss above, the process of multisited ethnography (e.g., Marcus, 1995) means that the research leads to, refines, and constrains the scope of investigation to suitably narrow units of analysis that resolve the scope of the question at hand.

The timeline included data about information generation and seeking activities from the field work, Wikipedia's VT pages editing activity; select Facebook groups; Flickr activity; and additional social networking, news media, and university Web sites. This attention to

Figure 2
Timeline of Selected On-Line and On-Site Activities During the First 9 Hours of Crisis



temporal detail was essential in accounting for and interpreting information dissemination and other activities, and placing them within a context of large-scale interaction.

CMC and Distributed Problem Solving

We next report on a subset of findings that describe some features of the social interaction that occurred after this event over multiple sites. Figure 2 summarizes central features of the postcrisis peer communications by depicting critical landmarks and trajectory activities during the first 8 hours of the event. The white entries mark the first and second shootings; the dark gray entries mark some of the information-dissemination critical activities by the university; light gray entries highlight significant peer-to-peer communications. The italicized text refers to broad activities (occurring both on-line and off-line) that have a larger set of data points than can be completely described in this timeline.

Strong Tie Safety and Welfare Checks

Although the emergency event, in hindsight, happened over the course of just about 2.5 hours (as marked by the first and second shootings), it was not until late afternoon

on the first day that students were told they could safely leave their dormitories. Our field data show (using a 24-hr clock) that during the period between the first shooting at 07:15 Eastern Daylight Time (EDT) (which made national news) and the second shooting at about 09:30 hr—*before* people realized that the second shooting happened—members of the VT campus were receiving and placing calls as well as making other forms of contact to family members off-campus. However, it was not until news of the second shootings became known that the information seeking activities became more pressing—for some, this was during the time of the shooting when they heard gunshots, but for those removed from the site of the crisis, this was not until about 10:16 EDT when an e-mail advisory to stay inside was sent. Parents in the meantime had already been speaking to their children, and so, in those situations, had been essentially talking to them preceding and during the time of the second shooting event. This provided retrospective reassurance in what became an increasingly more serious situation. Several reports indicate, in fact, that parents woke their children with a cell phone call, with this being the first notice of the event for many students. These *safety and welfare* behaviors are described as being part of the *inventory stage* (Dynes, 1970) when an individual takes stock of personal well-being, extends to welfare checking of close relationships, and moves to a collective inventory of what has happened.

Expansion to Diffuse Campus Social Networks

The 10:16 EDT e-mail message launched and expanded the safety and welfare checking to students' larger campus social networks. (We note that the focus of our data collection during this phase was with the student population—many of whom were on-campus or in nearby housing—though staff and faculty were working within the same decision space.) Students, who were told to stay inside (and found phone lines taxed from high traffic), turned to text and instant messaging (IM) to check the safety of friends located elsewhere. IM provided both concurrent and passive ways of communicating and ascertaining that "personal communities" of large, weakly tied networks of campus contacts (Wellman & Gulia, 1999) were safe. People could contact large numbers of others in a short time. These communications are also supported by what are called *awareness features* in ICT (Dourish & Bellotti, 1992), though design of such features is not always intentional and are an outcome of other implementation decisions. IM, by virtue of showing who is on-line and active, allows users to have cotemporal awareness of the presence of others. In the case of VT, if someone's IM "buddy" indicator was active, that person had to be on-line and therefore not injured. Groups on Facebook were used in the same way, except Facebook had the advantage of connecting thousands of VT students. On a college campus, where students (as well as faculty and staff) have large, diffuse social networks composed of many weakly tied (acquaintance) relationships (Granovetter, 1983), Facebook—already gaining ground as a destination for primarily college students at that time—was a powerful, virtual destination for crisis communication because it made it easier to detect who was safe simply by viewing on-line activity.

It was not long before these digital communications were complemented by newly spawned and more organized, explicit activities of direct inquiry and accounting. At 10:23 EDT, 7 minutes after the VT e-mail message indicating that a very serious crisis was unfolding, a post to a VT Facebook user's profile appears asking about her welfare—the earliest Facebook activity about the tragedy we have found. During this time, activity on

Wikipedia began at 11:16 EDT, within 1 hr of the official VT e-mail, indicating that classes on campus were cancelled. At 11:34 EDT, a VT student created a Facebook group called *I'm OK at VT*, which was intended to be a place for self-reporting one's safety. People began joining Facebook groups in great numbers. These rapid organizing activities around highly diffuse social networks set the stage for new ICT-enabled behavioral phenomena in crisis response that this particular event made tragically apparent, and which points to the highly socially distributed problem solving that can occur over the Internet.

Decentralized, Socially Distributed Problem-Solving Begins

Authorship traffic on the Wikipedia entry site quickly grew throughout the day as people contributed new information, particularly the names of the deceased (reaching a high at 15:00-16:00 EDT, with a total of 1,570 cumulative edits by that time). The activity within Wikipedia is indicative of what was happening at large and is an activity in disaster response that is newly enabled by pervasive and networked ICT. VT officials held a press conference at noon on the day of the event, at which they released information that 21 people were confirmed dead and 28 injured. At this point, we saw the launch of *widescale problem-solving activity* (Palen & Vieweg, 2008). Over a set of Web sites that were the focal points for this converging information, members of the international public began trying to determine who the victims of the crisis were (in a kind of "list-building" activity). People reported personal information they knew themselves or had seen posted elsewhere by others and began to create and expand on lists of the known victims. Such distributed problem-solving activity is decentralized with grassroots organization and is a characteristic of Castells' "network society" (2000).

When VT confirmed that the final death toll was 32 people plus the shooter at 14:13 EDT, this, we interpret, constrained the collective problem-solving space. Once we were aware of the list-building phenomena, we focused on a set of Facebook groups and a Wikipedia entry where such activity was taking place. (There were likely others, though the groups we examined had several pointers to them from elsewhere.) In our analysis, the *total compiled* information across all lists was a correct identification of the 32 victims, *before* VT released names to the public. What's more, the discovery of the names was not in the same sequence across lists nor was any list fully complete, indicating concurrent parallel problem solving and information gathering. In addition, although the peer-generated victim lists were compiled in different sequences, *they were never incorrect*. Participants in the list-building activities self-policed, and they knew that adding a name to the list was a serious statement. Accuracy, verification, credentialing, and gravitas ruled the interaction on these focal point sites (for a more detailed analysis, see Vieweg et al., 2008). On both sites (Wikipedia and Facebook), contributors participated in an editorial discussion that critiqued accuracy of the informal, citizen-originated information and their channels of communication, and how that information should be interpreted via formal channels.

Participation in the distributed problem-solving activity included family and friends—and students on behalf of them—seeking information about their missing loved ones. As one illustration, at 17:19 EDT, 10 hours after the first shooting had occurred, a post read: "If anyone knows anything of <name-of-victim> who was in Norris 207, please let me know." In what we call a *desperate move*, people turned to on-line forums—and in this

case, one designed to self-account—at a time when we speculate that most other sources had been exhausted.

The problem-solving activity period closed when university sources released names of all the deceased at 21:17 EDT on April 17, which confirmed the results of the collective research (partial sets were released earlier at 04:00 EDT in the morning and again at 19:15 EDT, but the citizen-led naming of victims still preceded these announcements).

Discussion

The data provide evidence of an emerging phenomenon of decentralized, highly distributed information production in the aftermath of the VT tragedy. This research, however, uncovers a particular and—because of the nature of the emergency—rather exacting instance of *collective intelligence* (Hiltz & Turoff, 1993) that resulted from the peer production of accurate information. Online activity included instances of significant investment in information gathering, generating, and sharing through peer channels—which included people who were remotely located and who also wanted to provide some kind of assistance. Official news announcements about the high number of fatalities and casualties launched information production and collation—primed by existing, social media-based safety, and welfare checking within students' extensive social networks—in a new direction, with self-organization around a well-defined task. The information volunteered and the help offered was in response to the incomplete knowledge about the scope and implications of the event. To remedy the problem of information dearth, the social arrangements of these distributed problem-solving efforts included fact-checking and source identification, which contrasts with rumor-mongering—the more usual way of reporting on public involvement in large-scale emergency response.

Disaster and crises are already events that perturb normal temporal ordering—they disrupt routine on a large social scale. In a networked world, which, as Castells (2000) theorizes, already creates a "new temporality" where the sequencing of events can be "disordered" or simultaneous (and also constructed anew), the combined conditions of disruption and rapid information production through ICT sets up new, often temporary, social structures in response. By organizing themselves through information tasks—production, sharing, aggregation, and manipulation—people are able to work in advance of conventional forms of news communication.

The VT case sadly illustrates this point because of the particular features of the emergency. As a violent crime with fatalities, officials were governed by laws and ethics about how they could release information until after the next of kin had been notified and forensics were completed. This created the conditions of a perceived absence of information—though for good reason—to which members of the public responded perhaps out of need to help and cope. The activity by the public on the Internet was not governed by those same conventions; people could rapidly organize themselves through the pooling of information around a focused task. More diffuse and protracted disasters like wildfire and hurricane with multiple unknowns and a wide set of problems faced by the public and responders make some particulars of collective intelligence activity harder to pinpoint in quite the same way, but we know they are occurring.

Even our choice of the term "crisis" rather than "disaster" or "emergency" (though we use all) to describe the domain of this work is revealing of the sociotechnical change arising in this area. Although we rely on the sociobehavioral studies of disaster to help explain what happens in an event that affects many people simultaneously, the sociological definition of "disaster" usually (but not always) pertains to a macroview of the social arrangements—that is, how organizations and institutions respond to the event. Disasters create particular kinds of organizational response that do not necessarily occur in other kinds of emergencies. Therefore, the term "disaster" is not used to describe school shootings, the participant of the case study here—which certainly does not mean that school shootings are not disastrous, only that the social arrangements around such events tend to be differently organized and driven. Although the definitions of disaster and other emergency terms are not precise (see Perry & Quarantelli, 2005), the pervasiveness of ICT means that behavior by members of the public will likely share similar features when similar tools are at hand. We therefore rely on disaster studies research to help explain what we see, but use the term *crisis* to describe, as best as terms allow, large-scale emergency activity by members of the public that includes disasters but also includes other unexpected events. In this, we hope to capture the changing practice of public response that is arising from the ease and rapidity of information production enabled by ICT. ICT-supported, socially distributed problem solving is giving rise to new social orderings in crises which are themselves a new way of framing what constitutes an emergency and at what scale.

The research suggests features of social interaction in a highly networked world where convergence of people, information, and media can create new environments—a new "space of flows" (Castells, 2000) within which collective action takes place. From this study, we can see how the social arrangements of emergency have the potential for significant change. Although crises will almost always have geographical connections that require that certain social interactions happen in place, much information production vis-à-vis the event no longer has those bounds. One can easily imagine a future where the number of personnel who converge on a geographical event following a regional disaster will not be nearly as many as once required. For example, the American Red Cross coordinates thousands of lay volunteers, flying them into a disaster region to manage a variety of unspecialized tasks—including tasks to then manage and mobilize the thousands of volunteers. Although there will remain countless rescue and recovery tasks that need to happen in the space of the event, much of the information production and dissemination work can happen remotely in both centralized and decentralized forms, leveraging an even greater pool of planned and emergent volunteers. In many crises, the information needs are vast and include not only the routing of tactical information to where it is needed during the emergency period—including that which originates from members of the public—but also ongoing logistics management around, for example, shelter occupancies and extended medical availability, management, and movement of emergency personnel and resources, and so on. This is information work that has been previously managed within the geographical region, even when those doing it have little local knowledge about the region itself—its roadways, landmarks, services, and geographical features—which can be a significant drawback to effective response.

The future of emergency management institutions will be operating in a world where activity by members of the public generates information on a far more expanded, rapid scale, with information production activity happening at even greater magnitudes than such

disruptive events already trigger. The reorganization of formal institutions is then inevitable, because they are based on ideas of centralized, command-and-control information distribution (Palen & Liu, 2007). One basis for that change must come from a fundamental shift in perspective—that large scale emergency response can (and will) take the shape of a distributed network of vast information sources and skills, including those collective skills and products generated by the public.

These concerns are central to the *crisis informatics* research area, with an agenda that is focused on the need to study the vast and heterogeneous data generated so we might then leverage and shape it into coherent and reliable real-time information sources. The research reported here involved mostly manual qualitative data collection and analysis techniques to examine the unexpected but relatively brief event, where certain new kinds of virtual resources (like Facebook) were used for the first time in an emergency of national concern. The attributes of this emergency provided temporal boundaries that helped scope the investigation, as well as constraints on the virtual destinations of import. However, this is not a scalable or sustainable approach for ongoing sociological investigation of emergency response. Crisis and disaster events are often more geographically and temporally diffuse than the VT event. As such, we must turn to tools that are being developed by the e-Social Science community for cyber-enabled data collection and analysis.

In addition, we must consider the need for new and more powerful data gathering and analytical solutions as a part of the core crisis informatics research agenda. We need tools that enable the integration of multimodal data sources—including on-site eyewitness video, interactivity on multiple social media sites, conventional and alternative news updates, and official notifications—into a coherent, time-based, and replayable information visualization environment much like the Digital Replay System (DRS; French et al., 2006; Greenhalgh, French, Tennent, Humble, & Crabtree, 2007). In particular, crisis informatics research—and subsequent information tools that arise from the work—will need to visualize multimodal data sources that can bring different data attributes into focus, depending on the event circumstances and research objectives. For example, because disasters are geographically bound (though the digital participation of people in such events is not), we need to be able to collect data resources that are localized to areas or points in space, including, for example, streaming video from an encroaching fire line, text messages with coordinates in that same area, and environmental sensor data. We might also want to trace particular pieces of information, as done in this research, and allow its diffusion across any number of virtual sites to automatically guide what information is visible to the analyst across time. In addition, our research program is incorporating natural language processing techniques to automate the requirements for this sort of information retrieval task.

It is our hope that emergency management can directly benefit from cyber-enabled analytic approaches, not only in terms of the investigative findings that address changing sociotechnical behaviors in such situations, but also because these same integrations and visualizations support the kind of real-time analytical activity that both members of the public and emergency managers already perform. Such a human-centered computing approach is at the foundation for reframing the information dissemination activities of emergency response as a collectively intelligent activity, the possibility for which was demonstrated in the aftermath of the tragic emergency discussed here.

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