

Collective Intelligence in Disaster: Examination of the Phenomenon in the Aftermath of the 2007 Virginia Tech Shooting

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ABSTRACT

We report on the results of an investigation about the “informal,” public-side communications that occurred in the aftermath of the April 16, 2007 Virginia Tech (VT) Shooting. Our on-going research reveals several examples of on-line social interaction organized around the goal of collective problem-solving. In this paper, we focus on specific instances of this distributed problem-solving activity, and explain, using an ethnomethodological lens, how a loosely connected group of people can work together on a grave topic to provide accurate results.

Keywords

Crisis informatics, disaster studies, collective intelligence, distributed cognition, distributed problem-solving, Facebook, Virginia Tech

INTRODUCTION

Disaster situations, throughout history, have demonstrated that people rise to difficult challenges to help others, often through remarkable innovations and adaptations of their own abilities and resources to meet needs (Tierney, Lindell and Perry, 2001; Kendra, Wachtendorf and Quarantelli, 2003). Recent disasters have made some of these behaviors more noticeable in light of increasingly pervasive information and communication technology (ICT). ICT has expanded the ways people can assist and involve themselves in disaster situations. In recent disasters, ICT has served as a means of expanded communication for disaster survivors, curious onlookers, and compassionate helpers wishing to aid those directly affected by crisis both inside and outside the geographical space of the disaster (Palen and Liu, 2007).

In this paper, we analyze a selected set of on-line interactions that occurred in the aftermath of the crisis at Virginia Tech, which represents a new and highly distributed form of participation by members of the public. We focus on this particular example because of the notable activity that took place on social networking sites following the shooting—sites that are increasingly used to maintain contact with peers under routine conditions, but found an extended purpose as an online destination for collective, distributed problem-solving. This activity was a clear demonstration of self-organizing that included the development of roles and norms that guided behavior around the sharing of sensitive information.

When dealing with crisis and disaster situations, public officials, including emergency managers and others responsible for the control and flow of crisis information, are concerned that uninformed citizens will spread rumors and inaccurate information. Yet time and again, disaster researchers have found that citizen activity often helps ameliorate tragedy and is necessary to disaster response and recovery (Stallings and Quarantelli, 1985). An instance of such constructive activity is examined here. We use an ethnomethodological lens that considers these critical interactions at the level of the discursive turn-take to explicate how people gathered on-line to aid and ‘make sense’ (Weick, Sutcliffe and Obstfeld, 2005) of a critical situation. The analysis pertains to one specific case discovered through and placed within a larger context of careful research, which makes some central points to establish this phenomenon as one that is worthy of scrutiny and further research.

The VT shootings occurred on April 16, 2007 in Blacksburg, Virginia, when a single shooter killed 32 people on the university campus. In an earlier paper, we consider the extended and ICT-enabled sociological arena of this crisis as news about the tragedy spread across the university, nation and world. That initial work described some remarkable

citizen-side information dissemination activities that arose in the aftermath, where people who were geographically distributed ‘discovered’ the names of the shooting victims by using on-line sites as points of gathering and collaboration well in advance of official news releases (see Palen, Vieweg, Sutton, Liu and Hughes, 2007). The work presented here continues our on-going work in the area of *crisis informatics*—a program of work that includes empirical study as well as socially and behaviorally conscious ICT development and deployment—and extends those findings to discuss features of this large-scale social interaction and its self-organization. We begin by first describing the particular problem-solving activities that have been our focus to set the stage for closer analysis.

AN INSTANCE OF COLLECTIVE INTELLIGENCE IN DISASTER¹

The tragedy at Virginia Tech happened on a Monday morning, when two people were killed during a first shooting that occurred at approximately 07:00 EDT,² and an additional thirty were killed during a second shooting that occurred between 09:30-09:50. Students, staff, and faculty were told to stay indoors as the crisis was unfolding, but it took some time before the scale of the tragedy could be known and communicated. When VT officials held a press conference at noon to announce that at least 21 people were confirmed dead and 28 injured, the commencement of large-scale, collective problem-solving began.

Using web sites (traditional media sites as well as social networking sites) that became the focal points for this converging information, members of the international public began trying to determine who the victims of the shootings were. People reported personal information they had access to or had seen posted elsewhere in a display of collective problem-solving. It is this activity that we focus on here—an example of *collective intelligence* (Hiltz and Turoff, 1993) where a large, distributed group of people who exhibited problem-solving capabilities came together on-line. Though a subset of these problem solvers leveraged the social dissemination of information in a directed fashion, the distributed activity is best understood as being emergent and collective rather than orchestrated.

When Virginia Tech confirmed the final death toll at 32 people plus the shooter at 14:13 (though not their names), the newly defined collective problem-solving space was constrained. Between specific Facebook groups as well as other sites and news outlets that served as feeders, people worked together to determine the identity of the victims. Among the list-building activities we studied, we found that while no one single list was complete by the time Virginia Tech released all 32 names, the total compiled information across all lists we analyzed was a correct identification of the 32 victims. Furthermore, the discovery of the names was not in the same order across lists, evidence that the phenomenon of distributed problem-solving occurred in multiple places in parallel.

The *I'm ok at VT* Facebook group was one place where some of this activity occurred. Though the initial purpose of this group was to simply join, thereby making one's own safety publicly known, *I'm ok at VT*, grew to serve a second purpose of supporting searches for and offers of information about VT students. Members asked about friends and acquaintances, and acted on behalf of others searching for relatives. We speculate that, at this point in time, when people decided to ask about the welfare of someone on a Facebook group, they likely had already exhausted other resources. This was what we call a ‘desperate move.’

The problem-solving activity period closed when university sources released all of the names of the deceased at 21:17 on April 17, confirming the results of the collective problem-solving activity. A partial set of names was released earlier at 04:00, and a second set at 19:15, but the citizen-led naming of victims still precedes these announcements. The empirical discovery of these parallel and distributed problem-solving activities was possible because of the particular constraints of this tragedy, which was devastating beyond description, but its short duration and localization resulted in a response that was large-scale but closely organized around particular places and points in time.

In the midst of these sense-making activities, our investigations did reveal another emergent form of on-line participation, one that we now describe as fitting into the stage of *remedy* (Powell, 1954) in times of disaster. Traditionally, *remedy*, which immediately follows the *rescue* phase of disaster, involves physical relief activities that respond directly to the needs of victims and survivors. Through our research, we have found that activities occurring at this stage also included significant investment in information gathering, generating, and sharing through peer-to-peer and official communications—particularly by people who were remotely located from the event. The

¹ Adapted from our earlier work found in Palen, Vieweg, Sutton, Liu & Hughes, 2007.

² All times quoted are in US Eastern Daylight Savings Time using a 24 hour clock.

information they volunteered and the research assistance they offered helped to remedy the dearth of knowledge following disaster (Palen et al, 2007).

The social arrangements of these distributed problem-solving efforts had several critical features that differentiated them from rumor-mongering, a more usual way of reporting on public involvement. The lists 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, and gravitas ruled the interaction on these focal point sites.

In this paper we focus on the social mechanisms that enable and guide decentralized and grassroots distributed problem-solving activity. Our approach uses the perspectives of discourse analysis and ethnomethodology (Garfinkel, 1967) for careful identification of features of the phenomenon that we were seeing more broadly. These same sensibilities are the bases for distributed cognition analyses of activity in socio-technical systems, with which we also align (Hutchins and Klausen, 1996; Hutchins and Palen, 1998). For this inductively-derived issue of distributed problem-solving in times of disaster, the research objective is showing that the phenomenon of collective intelligence *does*, in fact, exist, and can exist in a directed fashion around focused tasks with self-regulated and accurate results. Furthermore, the phenomenon runs counter to popular mythology around disaster behavior of civic post-disaster engagement as hysterical, prone to error, and even dangerous (Fischer, 1998)—a view that pervades current disaster management policy and technological orientations.

METHOD

Overarching Approach

In addition to the on-site interviews our team conducted at Virginia Tech (see Palen et al., 2007 for more detail), we collected on-line interactions from a variety of sources (including Flickr, English language Wikipedia, Facebook, Myspace, Orkut, Second Life), guided by our overarching interest in peer-to-peer communications in disaster events. Our archiving strategy developed iteratively. As we discovered more pointers to forums, we archived them. Though we discriminated where and when we could, we archived sites even if we were not sure they would prove important; our reasoning was to collect this data before it disappeared. Later, a sampling of the forums we archived became the subject of more focused ethnographic investigation and ethnomethodological analysis, once we built a high-level understanding of the activities that had taken place.

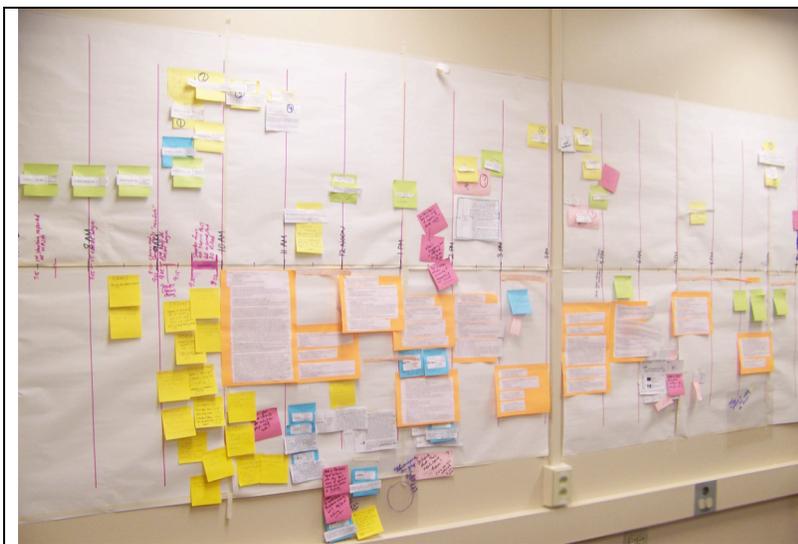


Figure 1. Timeline of Official and Unofficial Communications Data

Figure 1 shows the initial central analytical workspace—a detailed timeline of the first two days of the crisis that depicts critical informational events. We populated the timeline with data that pinpoint citizen-side communications (e.g., select Facebook, Wikipedia, Flickr and other activity) as accurately as possible (usually down to the minute) against official communications (university email, web postings, press conferences) from data collected across sites of interaction. This careful attention to temporal detail was essential to account for and interpret information dissemination and similar activities, and to place them within a context of large-scale interaction. As a second stage of investigation—one that this paper reports on—we conducted closer

analyses of interactions that help explain elements of the large-scale computer-mediated interaction we were seeing. In this paper, we report on analyses of a particular group in Facebook.

The Study Site

About Facebook

Facebook was an active destination for those wishing to discuss and find information about the events at Virginia Tech. Facebook is a social networking site that allows anyone to join, yet at the time of this event, was known for its popularity among college students. Once members designate "friends" within the system, they can see a range of information about their friends' Facebook-based activity. Members have their own public "profiles." Profiles list when users last logged in, messages that others have sent them, as well as what Facebook "groups" they and their friends have joined. Facebook communication is largely organized around the "wall" feature. "Walls" are a means of public messaging, and they exist both as personal walls—accessible by profiles—and "group" walls. Groups enable people with similar interests to come together; they can be created by anyone about any topic. Within groups, Facebook supports discussion and photo threads, providing multiple ways to communicate.

Selection of Facebook Groups

The unwieldy Facebook had over 500 groups that included the Virginia Tech Shooting as their topic; we considered these and archived 50 of these groups based on the following significant features: notable membership size, exchanges that centered on people's well-being such as "I'm OK" and "Are you OK" types of messages, groups that were started on April 16 with extended activity, and groups that had notable connections to other on-line forums (petitions, for example) or to the physical space of campus. Additionally, we set criteria to exclude groups focused on memorializing; not because memorialization activity is unimportant, but rather because this activity was abundant and already happening in the groups that we had retained for further study.

The *I'm ok at VT* group became the first focal point for our research due to the purpose it served regarding safety and welfare inquiries. A critical post there led us to another group, *Prayers for VT*, the focus of our discussion here. This group contained a discussion topic entitled *You know a student is confirmed dead? Compile the list here*, which had 103 posts by 44 people beginning at 21:34 on April 16. This was not the only Facebook discussion group working to solve the problem of victim identification. However, we placed our analytical focus on this group because of the palpable instances of its management of highly distributed problem solving activity.

Methodological Considerations

In presenting our data analysis, we were confronted with the problem of how to denote the names of victims. Though the names of the victims are public information, we are concerned about how our research, no matter how well-intentioned, treats this grave topic. Out of respect for the victims and their families, we chose not to list victims' names in their entirety—which seems exploitative—nor did we choose to use pseudonyms—which fails to honor the memory of the victims and historical basis of the tragedy. We instead use victims' initials to address these concerns. We gave pseudonyms to discussion participants, and anonymized affiliation unless it is Virginia Tech, which is helpful data. Data presented here resemble the posting style of Facebook.

ANALYSIS OF SOCIAL INTERACTION

What follows are highlights from an analysis of the *You know a student is confirmed dead? Compile the list here* discussion. We set out to answer the question: What were the social arrangements for managing the decentralized, distributed problem-solving which occurred outside official channels during this time of crisis?

The analysis is grounded in an ethnomethodological framework; it focuses on the micro-level detail of discursive exchanges between individuals participating in this Facebook discussion group. By paying close attention to the micro-level interactions, we are able to inform the macro-level sensemaking process that occurs in a distributed and decentralized fashion through social media. Detailed analysis of a single discussion group provides insight into the group structures that emerged over time and served to facilitate information sharing and to moderate the discussion tone as a sort of moral norm. Key here is that roles, structures, and norms did emerge in these collective forums and is an indicator that such behavior does and will occur during other times of crisis.

Authority and Authenticity

The discussion thread begins on April 16 with this post:

Mike T. (Virginia Tech) wrote
 at 21:34 on 4/16
Well I have heard from 3 confirmed names...RC(AJ), HL and LS

Mike T. does not give any references or sources, nor is he questioned by anyone about this news. Minutes later, the second post follows:

Aaron B. (Non-VT University) wrote
 at 21:42 on 4/16
**My roommate just found out that he lost a very dear friend MR
 pray for her family and her soul tonight... thank you**

By positioning themselves within circumstances that indicate access to privileged information, people who posted information like that from Aaron B. were apparently deemed to have significant authority to offer names; that is, they had sufficient 'social capital' (cf Bourdieu, 1991). Additional examples of such displays of social capital follow:

Mike T. (Virginia Tech) wrote
 at 23:51 on 4/16
CH as reported by a sorority sister.

Sam P. (Virginia Tech) wrote
 at 00:03 on 4/17
ML, one of my Air Force brothers. RIP

Chris S (Virginia Tech) wrote
 at 10:59 on 4/17
**I just finished speaking with his girlfriend, and it appears JH
 is a fatality as well.**
God rest his soul.

Such posts are not questioned for sources or authenticity, as those posting have explicitly qualified their access to this knowledge. This is in contrast to other posts, where participants are questioned about their authority to offer information, as the following sequence demonstrates:

Emily C. (High School) wrote
 at 22:38 on 4/16
JB and KG are also dead...

Jeff D. (Non-VT University) wrote
 at 22:50 on 4/16
What are your sources?

Jeff D. directly questions Emily C. about authenticity of information, and then immediately follows with his own demonstration of his expectations around establishing authenticity:

Jeff D. (Non-VT University) wrote
 at 22:51 on 4/16
Professor KG and Professor LL
 <provides link to the VT departmental website where both
 professors were members>

Emily C. responds, apparently attentive to the discussion at hand, citing other Facebook groups as the authoritative sources.

Emily C. (High School) wrote
 at 23:00 on 4/16
All the Facebook sites by the dozen

JB
KG
HL
RC
LS
EH
GL
JO
MT
RS
MR

**That's all I know currently, but there are still some people at
 the hospitable [sic?] who remain unidentified as well as I think
 three bodies that are also unidentified**

 Jeff D. (Non-VT University) wrote
 at 23:03 on 4/16
thank you

Emily C's qualification is apparently accepted as adequate, even though it internally refers to other Facebook groups. Perhaps the overarching norm under development here, then, is not that the information be proven to be correct, but rather that posters make "best attempts" at offering correct information. We take this to mean that within this community, Facebook is considered a reputable source. This exchange illustrates how posters are willing to offload doubt to the collective activity of Facebook; in other words, people might assume that other distributed activity—the collective intelligence—is resulting in correct or near-correct name lists.

This exchange is probably not just a demand that Jeff D. makes of Emily C., but also an attempt at norm-setting. Also noteworthy in this sequence is that Emily C. is the first person to list the known victims at this point—this is a significant discursive move. Going forward, the practice of listing of the victims becomes increasingly more common, which we see as another instance of norm-development.

Accuracy and Policing

Another sequence of posts on April 17 reveals high concern about accuracy:

David A. (Non-VT University) wrote
at 11:29 on 4/17
where was WS confirmed?

Carrie T. (Non-VT University) wrote
at 11:42 on 4/17
<list of 27 victims and the shooter>

Sorry for the confusion earlier... WS is not confirmed although he is still missing.

We note that an important piece of this interaction probably occurred just before this 11:29 post by David A. Our data set shows that a post was deleted, though we do not have access to it. David A.'s inquiry and Carrie T.'s response suggest that the deleted post pertained to WS. At that point in time, WS was not a confirmed victim, though it seems information was circulating that he was. Since this group did not have sufficient evidence to name him on their victim list, he was not added.

Leveraging the Collective Intelligence

Brokering

We continue to see evidence that Facebook-based communications are perceived to be a respected source of information in the following sequence:

Mara W. (City) wrote
at 23:20 on 4/16
Another confirmed name: JL.
<link to a Facebook site>

In the next three messages, Mike T. appears to be taking a discursive cue from Mara W., who listed a Facebook site as an authoritative source. Mike T. posts 4 minutes later referring to "a Facebook message":

Mike T. (Virginia Tech) wrote
at 23:24 on 4/16
DP as reported to me by a facebook message

...and then in short order delivers other Facebook-based information.

Mike T. (Virginia Tech) wrote
at 00:01 on 4/17
BB confirmed by his facebook

Mike T. (Virginia Tech) wrote
at 00:09 on 4/17
RS as reported to another facebook group

In the three instances above, Mike T. appears to be culling Facebook for information about victims (all of which turns out to be correct). Mike T. is a kind of 'information broker' —someone who receives or gathers information from one source and reports it within another. Furthermore, he is gathering information generated by a collective intelligence, and redistributing it. We also note that his VT affiliation may serve as a credential for his prominent role in the group.

List Building

Beginning around midnight on April 17, the collective problem-solving involves rapid activity surrounding the posting of lists:

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Mara W. (City) wrote
at 00:08 on 4/17
<list of 16 names>
Total list so far: 16

Mike T. (Virginia Tech) wrote
at 00:09 on 4/17
RS as reported by another facebook group.

David A. (Non-VT University wrote
at 00:10 on 4/17
It's 17:
<list of 17 names>

Jose M. (Non-VT University) wrote
at 00:15 on 4/17
18 now:
JB
KG
HL
RC
LS
EH
GL
JO
MT
RS
MR
LL
JL
DP
CH
BB
ML
RA?

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Of note here is the question mark after the last name, RA. Jose lists 18 victims, but is unsure about RA. Jose M's use of a question mark suggests that though he did not have a source to support his listing of RA, he thought that it was likely to be accurate. However, we also interpret the question mark as a request to the collective intelligence for verification. One minute later, we see a response to that question mark with this:

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Andrea G. (City) wrote
at 00:16 on 4/17
RA... just from another facebook group... <link to Facebook group>

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The list building continues, with sources from primarily Facebook groups as well as personal social contacts and news outlets. The VT student newspaper website was an official outlet for the university, and released names in three separate groups; it served as a resource for verification of information found elsewhere before those official releases. At this point, it is evident that Facebook was considered as reliable as news media sources. At 11:42 on April 17, the list of victims in this discussion thread is at 27; by 12:06 at 28. We then see some discussion surrounding source validity:

Jan H. (Non-VT University) wrote
at 12:18 on 4/17
<alternative media site>. That website is not accurate i dont think. it said LM was in critiical condition and that is not confirmed at all.

(LM had actually just been accurately listed as one of the deceased in the list posted at 12:06, which this poster must have missed.)

David A. (Non-VT University) wrote
at 12:20 on 4/17
That site is OK.. some of it is speculation and rumor. I'm pretty sure we have the best most up to date confirmed list here.

In addition to Mike T., David A. had been acting as one of the primary information brokers. His appraisal of the VT student newspaper was that it was less than exemplary, while his assessment of this Facebook group is quite good. According to him, the information collation occurring within this Facebook group is "the best and most up-to-date"; that is, informal, citizen communication is superseding the news media sources in both accuracy and timeliness.

Evidence of a Problem-Solving Space

After the 15:54 post by Mike T., there is a lag before the next post appears 5 hours later. Up until this point, the listing of victims by this group precedes official announcements. This 20:24 request attempts to reignite a stalled discussion to see if the final 3 victims can be determined, bringing the list up to meet the number of 32. (Virginia Tech will intercede with the release of the full list of names at 21:17, but of course the group could not know this at this time.)

David A. (Non-VT University) wrote
at 20:24 on 4/17
Has anyone heard about these last 3 names? It seems like all information on every website has just stopped.

At 21:16, David A. starts to get some responses, just as Virginia Tech prepares to release the final names:

Joe R. (Non-VT University) wrote
at 21:16 on 4/17
According to someone on the <alterative media> site,, ZZ³ is among the deceased.

Mary E. (City) wrote
at 21:26 on 4/17
**According to this article: <link to a CBS news article>
ZZ's death would raise the total to 34 (including the shooter) as was still alive three hours ago. :(**

³ We use a pseudonym here because ZZ was not a fatality victim.

Of particular interest in the above posts is the reference to the number of victims, and how this exchange once again establishes that these participants have the common goal of finding who the 32 victims are; reaching that goal is the purpose of this group, and that number has therefore become a salient point. David's question reminds the audience about the upper-end constraint; Mary E. writes in response, explaining how listing ZZ changes the upper-end constraint that they have been working towards most likely because, in the middle of this exchange, Virginia Tech released the final set of names (at 21:17). Adding one changes the goal, as well as presumably the dynamic of the group's interactions.

CONCLUSION

The data we present here provide evidence of an emerging phenomenon of highly distributed, decentralized problem-solving that, in the tragic case of Virginia Tech, occurred in a concentrated, well-intentioned, and earnest fashion. The work done by the particular Facebook group presented in this paper is just one case of several we found in our extended data analysis work. The behavior we see exhibited is in striking contrast to the typical ways in which activity by the public is portrayed, which is one in need of policing and control. A long history of disaster sociological work has shown that that particular view of public behavior is misguided, and that, instead, people form altruistic communities (Fischer, 1998; Tierney et al., 2001), which include the sort we now see on-line.

Here, instead of rumor-mongering, we see socially-produced accuracy. How does this happen? In our study, the participants, who were working within a kind of 'discourse around death'—where respect for the victims and their families demanded accuracy—established expectations for behavior about how information about victims was to be treated. Participants had to legitimize themselves as authorized 'speakers' of information when reporting names of the deceased by citing sources. When participants were unsure of reports, they requested corroboration by others.

Our empirical attention to this particular activity in the aftermath of the Virginia Tech tragedy is *not* done to say that the public at large 'should have' received information about the victims any earlier than they did—this is not a call for 'faster, more open' communications from the formal response. Our attention to this activity instead highlights an instance of the kind of on-line collective action of which we will see increasingly more, and that this tragedy unfortunately lets us understand in detail. Members of the public at large were spurred to action when the total number of fatalities was announced. This set out a clear and closed problem space for them to work within—and for us to then more confidently study—and historically demonstrated that such activities can and do take place. Larger-scale disasters with more dispersed and open information dearth problems make this kind of behavior harder to 'see' in such a focused and empirical sense, but that is not to say that it does not occur.

These activities are evidence for the kinds of citizen-side work that will likely intensify in the future—that of ICT-enabled, socially distributed coordination by people affected by disaster, and by the many others who want to help. The results of this initial study offer proof that these kinds of concentrated, grassroots efforts can and do occur, and show that ICT-supported civic participation has the means of playing an important role in disaster response. Activities around establishing policy, practice, and —now—new technological development would be remiss to dismiss it.

ACKNOWLEDGEMENTS

We extend our deepest sympathies to the families and friends of the victims of the crisis, and to the Virginia Tech community. The authors are appreciative of the students, staff and faculty of Virginia Tech 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. This research is supported by the National Science Foundation: IIS-0546315; CMMI-074304 and a Graduate Fellowship awarded to the third author. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

REFERENCES

1. Bourdieu, P. (1991) *Language and Symbolic Power*, Cambridge: Harvard University Press.
2. Fischer III, HW. (1998) *Response to Disaster: Fact Versus Fiction & Perpetuation*, 2nd ed., Univ Press of America: NY.
3. Garfinkel, H. (1967) *Studies in Ethnomethodology*, Englewood Cliffs, NJ: Prentice-Hall.

S. Vieweg, L. Palen, S. Liu, A. Hughes, J. Sutton (2008). Collective Intelligence in Disaster: An Examination of the Phenomenon in the Aftermath of the 2007 Virginia Tech Shooting. *Proceedings of the 5th International ISCRAM Conference*, Washington DC, USA, May 2008.

4. Hiltz, S.R. and Turoff, M. (1993) *The Network Nation: Human Communication via Computer*, Cambridge: The MIT Press.
5. Hutchins, E. and Klausen, T. (1996) Distributed Cognition in an airline cockpit, In Engeström and D. Middleton (eds) *Cognition and Communication at Work*, Cambridge University Press, 15-34.
6. Hutchins, E. and Palen, L. (1998) Constructing Meaning from Space, Gesture and Speech, In L.B. Resnick, R. Saliho, C. Pontecorvo and B. Burge (eds.) *Discourse, Tools and Reasoning: Situated Cognition and Technology Supported Environments*, Springer-Verlag, Germany.
7. Kendra, J. M., Wachtendorf, T. and Quarantelli, E.L. (2003) The Evacuation of Lower Manhattan by Water Transport on September 11: An Unplanned Success, *Joint Commission Journal on Quality and Safety*, 29, 6, 316-318.
8. Palen, L. and Liu, S. (2007) Citizen communications in disaster: Anticipating a future of ICT-supported public participation, *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 727-736.
9. Palen, L., Vieweg, S., Sutton, J., Liu, S.B. and Hughes, A.L. (2007) Crisis Informatics: Studying Crisis in a Networked World, *Third International Conference on e-Social Science, Ann Arbor Michigan*, October 7-9, 2007, <http://ess.si.umich.edu/papers/paper172.pdf>.
10. Powell, J. W. (1954) *An Introduction to the Natural History of Disaster*, University of Maryland: Disaster Research Project.
11. Stallings, R. and Quarantelli, E. (1985) Emergent Citizen Groups and Emergency Management, *Public Administration Review*, 45, 93-100.
12. Tierney, K., Lindell, M.K. and Perry, R.W. (2001) *Facing the Unexpected: Disaster Preparedness and Response in the United States*, John Henry Press: Washington, DC.
13. Weick, K., Sutcliffe, K. and Obstfeld, D. (2005) Organization and the Process of Sensemaking, *Organization Science*, 16, 4, 409-421.